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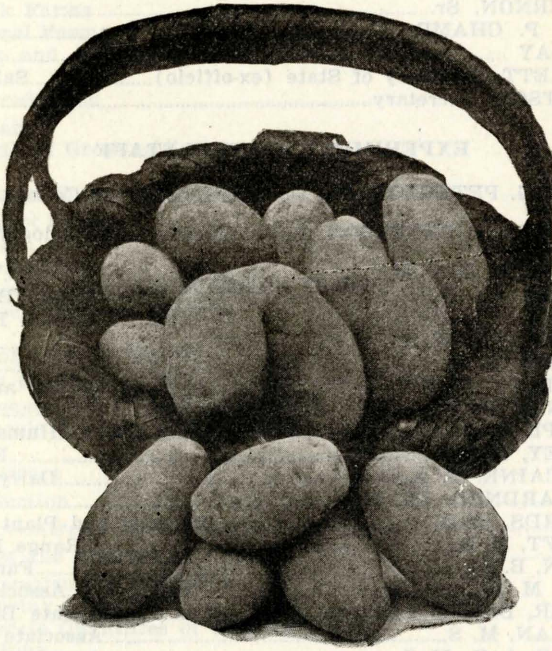
CIRCULAR 58 NOVEMBER, 1925

(Revision of Circular 40)

# POTATO PRODUCTION IN UTAH

GEORGE STEWART



# UTAH AGRICULTURAL EXPERIMENT STATION

LOGAN, UTAH

# UTAH AGRICULTURAL EXPERIMENT STATION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# POTATO PRODUCTION IN UTAH*

By
GEORGE STEWART

## INTRODUCTION

Potatoes were the first crop planted in Utah. In July 1847, the Mormon pioneers turned the water from City Creek over the parched land near what is now the center of Salt Lake City. The ground was then broken and sown at once to potatoes. Only a small yield was obtained but this helped materially to eke out the meagre food supply until the harvest of 1848. During the several hard years that followed potatoes were among the most important foods for the pioneer settlers. Since then they have held a prominent place in the agriculture of the state.

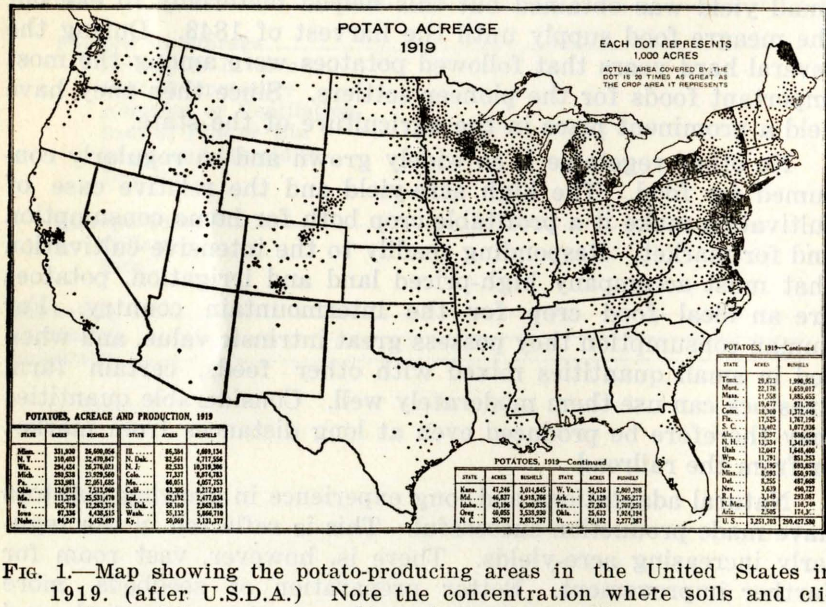
No other vegetable is so widely grown and so regularly consumed for food. The high acre-yield and the relative ease of cultivation make it a profitable crop both for home consumption and for market. Responding readily to the intensive cultivation that must accompany high-priced land and irrigation, potatoes are an ideal food crop for the intermountain country. For human consumption they possess great intrinsic value, and when fed in small quantities mixed with other feeds, certain farm livestock can use them moderately well. Considerable quantities may therefore be produced even at long distances from market or from the railroad.

Natural adaptations and long experience in growing potatoes have made production successful. This is reflected in the regularly increasing acre-yields. There is, however, vast room for further improvement. Better preparation of seedbeds, more careful seed selection, better methods of disease control, and wiser irrigation are all comparatively simple and inexpensive; yet they would greatly increase both the yield and the quality of Utah's potato crop. This is true not only on farms that grow potatoes almost entirely for home consumption but on those farms which grow truck potatoes for city markets and also on those which produce sufficient quantities of the general crop for interstate shipment. All growers in the intermountain states can improve in some phase of potato production and most of them in several. No known region has yet made such progress in potato-growing as to have no more lessons to learn. To this rule the farmers of Utah are not an exception.

*Revision of Utah Experiment Station Circular No. 40.

## POTATO-PRODUCING REGIONS

Altho native to America potatoes are now produced in greatest abundance in Europe, where from 80 to 90 per cent of the world crop is grown. Most of the other 10 to 20 per cent is produced in the United States, Canada, Asiatic Russia, Japan, and Australia. In order of importance the producing nations rank as follows: (1) Germany, which produced about one-fourth of the world's crop, (2) Poland, (3) European Russia, (4) United States, (5) France, (6) United Kingdom, (7) Belgium, (8) Netherlands, (9) Spain, and (10) Canada.




POTATOES, ACREAGE AND PRODUCTION, 1919

| STATE | ACRES | BUSHELS | STATE | ACRES | BUSHELS |
|---|---|---|---|---|---|
| Minn. .. | 331,930 | 26,600,056 | Ill. ..... | 86,384 | 4,609,134 |
| N. Y. .... | 310,403 | 32,470,847 | N. Dak. . | 82,561 | 4,717,556 |
| Wis. ... | 294,424 | 26,376,023 | N. J. . | 82,533 | 10,319,306 |
| Mich. .. | 280,538 | 23,929,560 | Colo. ... | 77,337 | 8,874,783 |
| Pa. .... | 233,981 | 22,051,685 | Mo. .... | 66,051 | 4,057,753 |
| Ohio ... | 124,917 | 7,513,960 | Calif. ... | 63,305 | 8,217,937 |
| Me. .... | 111,378 | 25,531,470 | Ind. .... | 62,192 | 2,477,034 |
| Va. .... | 105,789 | 12,263,374 | S. Dak. . | 58,180 | 2,863,186 |
| Iowa ... | 97,336 | 4,438,515 | Wash. .. | 55,132 | 5,866,710 |
| Nebr. ... | 94,247 | 4,452,497 | Ky. . | 50,069 | 3,131,377 |

POTATOES, 1919—Continued

| STATE | ACRES | BUSHELS | STATE | ACRES | BUSHELS |
|---|---|---|---|---|---|
| Kans. . | 47,246 | 3,014,845 | W. Va. . | 34,526 | 2,809,298 |
| Md. ... | 46,837 | 4,918,766 | Ark. ... | 24,128 | 1,765,277 |
| Idaho .. | 43,196 | 6,300,835 | Tex. ... | 27,263 | 1,707,251 |
| Oreg .. | 40,055 | 3,538,930 | Okla. .. | 25,633 | 1,924,194 |
| N. C. .. | 35,797 | 2,852,797 | Vt. .... | 24,182 | 2,277,387 |

POTATOES, 1919—Continued

| STATE | ACRES | BUSHELS |
|---|---|---|
| Tenn. . | 29,873 | 1,990,951 |
| Mont. . | 22,178 | 1,659,017 |
| Mass. . | 21,558 | 1,885,655 |
| La. .... | 19,677 | 971,705 |
| Conn. . | 18,300 | 1,372,449 |
| Fla. ... | 17,525 | 1,767,196 |
| S. C. .. | 13,402 | 1,077,936 |
| Ala. ... | 13,397 | 886,450 |
| N. H. .. | 13,334 | 1,341,978 |
| Utah .. | 12,047 | 1,648,400 |
| Wyo. .. | 11,791 | 851,253 |
| Ga. ... | 11,195 | 693,857 |
| Miss. .. | 8,993 | 650,970 |
| Del. ... | 8,255 | 487,668 |
| Nev. .. | 3,639 | 490,727 |
| R. I. ... | 3,149 | 293,087 |
| N. Mex. | 3,070 | 110,748 |
| Ariz. .. | 2,505 | 174,3[illegible] |
| U. S. ... | 3,251,703 | 290,427,580 |

FIG. 1.—Map showing the potato-producing areas in the United States in 1919. (after U.S.D.A.) Note the concentration where soils and climatic conditions are favorable and near large cities.

Because of their high water content (about 78 per cent) in proportion to their value and their perishability, potatoes are not important in the foreign trade of any country. Even Germany consumes all of her enormous crop. The United States has practically no foreign commerce in potatoes; as an average for twenty years the exports amount to barely more than a million bushels annually, and the imports to slightly more than two million bushels. Most of the exports and imports are due to convenience in transportation rather than to the operation of the laws of supply and demand.

The northern tier of states from Minnesota eastward grow by far the larger part of our total potato crop. Table 1 gives the

5-year average (1920-1924, inclusive) acreage, acre-yield, production, and farm price. Out of a total of 414 million bushels for the whole United States, the six states of Maine, New York, Pennsylvania, Michigan, Wisconsin, and Minnesota grew about half.

TABLE 1.—The 5-year (1920-1924 inclusive) average acreage, acre-yield, production, and farm price of potatoes for six leading states, for Utah, and for the whole United States arranged in order of total production.

| State | Average Acreage | Average Acre-yield (bushels) | Average Total Production (bushels) | Average Farm Price Dec. 1 (cents) |
|---|---|---|---|---|
| New York | 330,000 | 120 | 39,673,000 | 88 |
| Minnesota | 381,000 | 100 | 37,579,000 | 54 |
| Michigan | 330,000 | 107 | 35,063,000 | 60 |
| Maine | 129,000 | 245 | 31,467,000 | 74 |
| Wisconsin | 283,000 | 105 | 30,586,000 | 59 |
| Pennsylvania | 249,000 | 106 | 26,449,000 | 103 |
| Utah | 18,000 | 174 | 2,890,000 | 70 |
| United States | 3,851,000 | 108 | 414,880,000 | 85 |

Utah's average production is 2,890,000 bushels. This is about one-third as great as the production of California, one-fourth as great as that of Colorado, one-fourth that of Idaho, twice that of Wyoming, and six times that of Arizona. The state of New York alone produces nearly as many potatoes as all the Intermountain and Pacific Coast States. New York and Minnesota together produce almost 1½ times as many bushels as the eleven western states, whose yield is about fifty million bushels. Utah's production is somewhat less than one-tenth that of New York, Michigan, Minnesota, Maine, or Pennsylvania.

Potato production has developed rather rapidly in the West, as regards both acreage and acre-yields. The acreage in Utah increased from less than 9,000 acres in 1882 to more than 12,500 in 1889. Then, probably due to an era of poor prices, the acreage decreased to between 5,000 and 7,000 acres during the period from 1889 to 1900. Then came a rapid increase. There were 5,500 acres in 1900, 15,000 in 1909, and 23,000 in 1917, after which there was a decrease to 14,000 acres in 1924 and 1925. The decrease the last few years is due in part to the expansion of the sugar-beet industry. Acre-yields have also increased, not regularly year after year, but rather uniformly if longer periods are considered. Statistics are available for the 44 years from 1882 to 1925. If these be divided into four 9-year periods and one 8-year period—1882-1890, 1891-1899, 1900-1908, 1909-1917, and 1918-1925—the average acre-yields are 87, 124, 140 and 162, and 170 bushels, respectively.

Rapid as has been the development of the potato industry in Utah, it has been even more rapid in Idaho, Colorado, and Washington. California developed much earlier, but has also shown a rapid increase in acreage since 1882, when Utah's statistics were first reported separately.

## THE PLANT

**History.**—The potato was growing wild in the valleys of Ecuador when the Spaniards first visited that part of America about 1534. This useful plant made its way into Virginia and North Carolina in time to be carried to England and Ireland by Raleigh's expedition in 1586. In Ireland it did so well that it soon became the principal food crop; so important did it become that a failure due to late blight caused a general famine in 1846. During this year and the next, more than 300,000 people died of starvation and other thousands left the country. Meantime, the Indians and whites in the neighborhood of Jamestown gradually increased their dependence on the potato until, by the first of the eighteenth century, they used it generally. By the middle of that century, it had spread into those parts of Europe favorable to its growth and gained larger and larger footholds on account of its high acre-yields. In thickly populated districts just such a food crop was needed.

**Relationships.**—Botanically the potato is *Solanum tuberosum.* There are about sixteen hundred species in the potato family, and nine hundred of them in the same genus; only six of the species in the potato genus, however, bear tubers. Besides the ordinary potato, only *Solanum commersonii* is important. It is disease-resistant, but yields poorly. Among the immediate relatives of the potato is the tomato, which is so closely related that parts of one plant may be grafted on the other. Tobacco, nightshade, henbane, and belladonna also belong in the same family.

**Description.**—The plant originally propagated itself by means of seed, but man has propagated it so long by means of tubers that contain buds, or "eyes", that the seed is seldom or never considered. The buried "set", as the cut piece of tuber is called, sends out a stem which bears leaves after reaching sunlight. The length of this underground stem depends on the depth of planting. At various places on this stem new branches, or stolons, grow horizontally outward, and some of them bear

FIG. 2—Diagram of potato plant. Note the slender unbranched stolons on which the tubers are borne.

tubers at the end. From two to four roots grow from the upright stem at the base of each tuber-bearing stolon.

By the time of maturity, the fibrous roots have spread for twelve or eighteen inches and have extended four or five feet into the soil if it is loose and well-drained. Tubers from one to thirty in number, varying from the size of a pea to six pounds, have been found in a single hill. Six or more potatoes about the size of the double-fist are preferred. The angular stem, which varies from one to five feet in length, with a usual height of about two or two and a half feet, stands upright or droops across the open space, depending on the variety and on the soil conditions. The leaves are compound with small leaflets growing in the axil and scattered irregularly between the thick, pointed, oval leaf-parts, which are from one to three inches long.

Buds, or eyes, are borne sparsely at the stem end and close together at the bud end of the tubers. A string passed around the tuber and held in position with a pin in each eye shows a spiral arrangement of the eyes. Cross-sections of a tuber show three nearly concentric parts and one irregular part. The outermost, the external cortical, is poor in starch and so thin as to be almost entirely removed in peeling. Then comes a thicker layer, rich in starch and called the internal cortical, which in turn surrounds the external medullary also rich in starch. The dark-colored core, the internal medullary, is watery and low in starch. A potato that contains a proportionately large external medullary and internal cortical is desirable on account of its high starch content which gives the potato the quality of mashing readily when cooked. Potatoes that are yellow and soggy after cooking are undesirable in America, where they are usually baked or boiled, but are highly prized by the French who serve them fried.

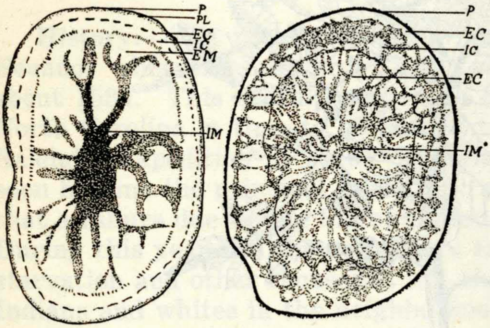


FIG. 3.—Diagram showing cross section of potato tuber. Good quality (right); poor quality (left). P, epidermis; PL, Pigment; EC, external cortical; IC, internal cortical; EM, external medullary; IM, internal medullary (dark-colored).

## PLACE IN THE CROPPING SYSTEM

Potatoes may be grown in various cropping systems, if the proper soil condition exists. Tho there are many systems of crop rotation or partial rotation in Utah, general systems for these three groups of farms require attention: (1) truck farms on which neither alfalfa nor grain is the basic crop; (2) general farms on which alfalfa and potatoes, or alfalfa, potatoes, and sugar-beets are the principal crops; and (3) farms on which grain or sugar-beets, or both, is the principal cash crop and on which potatoes are grown merely for home consumption. Grain is usually of small consideration in the first group; of only moderate importance in the second; but together with alfalfa, or alfalfa and sugar-beets, of primary importance in the third.

**Truck farms** grow neither alfalfa nor grain as a principal crop. Trucking in Utah is confined almost entirely to Boxelder, Weber, Morgan, Davis, Salt Lake, and Utah Counties. The land is too high-priced for grain and not much alfalfa is grown because the farms are too small successfully to compete with those that are both considerable in extent and at the same time fairly well-stocked with dairy cows or with other livestock. On such farms canning peas are just beginning to be grown. Leguminous crops, including sweet clover are necessary to keep up the nitrogen supply of the soil and to afford some semblance of rotation where alfalfa is not produced. It is probably advisable to grow potatoes only once in three or four years, altho under some circumstances more frequent crops prove profitable. In some cases lettuce, garden beets, or other late crops may be sown after early potatoes are harvested, thereby enabling the land to do double duty.

**On general farms** where potatoes and sugar-beets together with alfalfa form the principal crops, alfalfa furnishes hay and also serves as a nitrogen restorer; potatoes or potatoes and sugar-beets are the cash crops; usually some cereals are grown for silage or grain. One rotation that would probably be successful under such conditions is alfalfa four or five years, corn for silage one year, potatoes one year on corn land manured in the fall, beets one year with some manure, peas one year, beets one year with manure to supplement the pea residues, and small-grain one year to serve as a nurse crop for alfalfa, or to be taken off early, and the alfalfa sown after it is harvested. If corn is not grown, potatoes may follow alfalfa, making the cropping system alfalfa, potatoes, beets with manure, peas, beets with manure, and grain. Potatoes might also be grown just ahead of the nurse crop of grain instead of beets. Some farmers grow potatoes oftener than this, but in general diseases are likely to cause trouble if this is done. Another possible rotation would be alfalfa, potatoes, beets or grain, peas, potatoes, and alfalfa with or without a nurse crop. In this case peas would serve as an additional cash crop and also as nitrogen gatherers, to break the long period between two alfalfa crops.

**Where only grain and alfalfa** or grain, alfalfa, and sugar-beets are grown extensively, with a small acreage of potatoes mainly for home use, a still different arrangement is necessary. A possible rotation would be alfalfa five or six years (in some sections seven or eight and in others only three or four), corn, small-grain, peas, corn with manure, or small-grain as a nurse crop for alfalfa. One or two acres of potatoes, more often a half acre, may be thrown into the rotation at one of several places. Just after alfalfa is perhaps the best place. If silage corn follows alfalfa, a piece of corn land may be well manured in the fall before fall plowing. Another good place is after peas with some manure turned under to supplement the residues. In this cropping system potatoes should receive the utmost care because only a small acreage is grown and because they can fit in almost anywhere without upsetting any other crop. Some farmers find it highly profitable to plant potatoes only on land freshly broken from alfalfa sod. Fall breaking is then of the utmost importance. Often it will be profitable to add a thin coating of rich manure to the alfalfa stubble before breaking, especially if the alfalfa is thin.

Generally there is no good reason for growing potatoes more often than once in six to ten years on the same land, unless it so happens that only a small part of the farm is good potato soil. In this case it might be wise to rotate as thoroly as possible and in the meantime prepare another small area by heavy manuring, by the growth of alfalfa, or even by the addition of sand or small wood chips or sawdust, if the land is decidedly compact.

## FACTORS IN PRODUCTION

Aside from the ordinary cultural operations, six major factors markedly affect potato production. These factors are: (1) climate, (2) selection of soils, (3) supply of organic matter, (4) soil moisture, (5) seed selection, and (6) disease control.

### CLIMATE

Climate is the most important single factor affecting potato production. Fairly good potatoes can be obtained on almost any kind of soil with ordinary cultural methods where the climate is highly favorable. On the other hand, no degree of attention to soil, seed selection, soil moisture, or fertilizing can overcome the drawback of too hot a climate. On this account practically all the potatoes grown in the United States are produced in the northernmost states except in the mountain section where high altitude largely overcomes the bad effect of low latitude. Too much cold weather, of course, is fatal.

A survey of European potato-producing countries shows that the best regions are considerably farther north than the Canadian boundary, in fact as far north as Labrador which is too cold and bleak even for crops much hardier than potatoes. The warm

Gulf stream, however, so moderates these European climates as to counterbalance the effect of high latitude. The seasons of Scotland, Belgium, Holland, northern Germany, and southern Scandinavia are long, moderately moist, and uniformly cool. Irregular coastal lines further accentuate this by bringing the cool, moist, oceanic climate to a much larger area than is the case with the United States. The long days of northern summer materially increase the number of hours of daylight, and in starch production light is an important factor. It is this highly favorable climate coupled with intensive farming, intelligent seed selection, and disease control that makes possible the high acre-yields of European countries. In Scotland which represents the acme of climatic adaptation, Lord Roseberry reports acre-yields of approximately 2,000 bushels. In the hotter American climates 1,000 bushels is extremely rare. The acre-yield of Belgium is 307 bushels; of the Netherlands, 269; of Great Britain and Ireland, 215; and of Germany, 205. Hotter southern, and hotter or drier interior Europe have much lower yields,—Russia 106, Austria-Hungary 136, France 125, and Spain 123. The average for the whole United States for the same period was 97.5 while Maine with a more northern and more oceanic climate grew 205 bushels an acre. The acre-yields of Montana, Idaho, Washington, and Utah, are 141, 159, 142, and 162 bushels, respectively, as against 90 bushels for New Mexico, and 101 for Arizona. The northern counties of Utah show yields as follows: Boxelder 183.2 bushels, Cache 175.4, and Rich 191.1. The hot southern counties yield much less—Grand, 83.2 bushels, San Juan 59.3, and Washington 127.2. Morgan, another cool county of northern Utah, yields 196.6. In Beaver County potatoes have been nearly all produced in a higher and therefore a cooler valley. Here the acre-yield is 167.2 bushels.

TABLE 2.—The Yield of Early Ohio Potatoes Dug on Different Dates

| Date of Digging | Total (bushels) | Total (marketable) | Gain (marketable) Bu. a day | Per cent Foliage Dead |
|---|---|---|---|---|
| July 31 | 38.7 | 10.9 | ..... | 0 |
| August 7 | 87.7 | 62.3 | 7.5 | 1 |
| August 14 | 141.5 | 115.4 | 7.6 | 8 |
| August 23 | 203.2 | 182.1 | 7.2 | 22 |
| August 30 | 253.8 | 226.8 | 6.4 | 99 |

**Length of growing season** is also important. Potatoes make most of their growth late in the season. Table 2 shows data from Minnesota bearing on this subject.

Late potatoes continue their growth until well into October in some sections. Slight frosts are not so nearly fatal to potatoes as they are to beans or to corn.

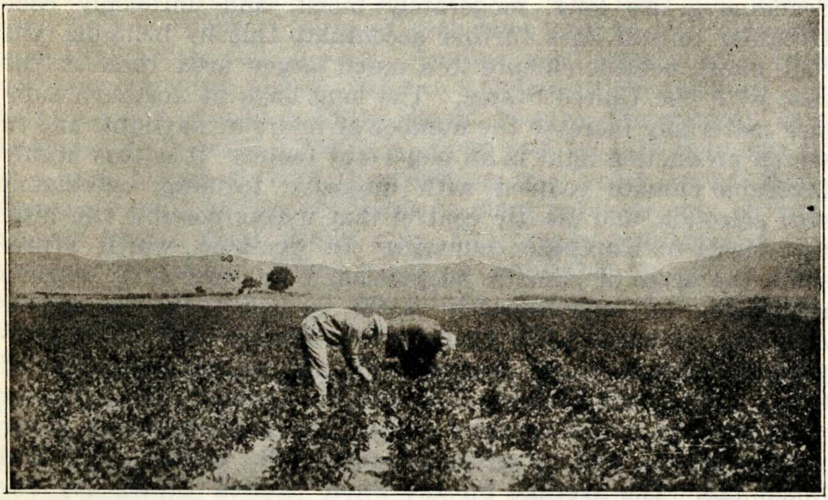


FIG. 4.—A field of good potatoes during growth.

## SELECTION OF SOILS

Potatoes thrive best on warm, porous soils that are at the same time fertile and retentive of moisture. Tho not to their best advantage on either clayey or gravelly soils, they can be grown successfully on such soils if care is taken to put them in proper condition. Mineral plant-foods are required in abundance. Phosphorus and potassium must both be readily available, the draft being much heavier on potash. With these two elements most Utah soils are abundantly supplied. Nitrogen, required in moderate quantities, is probably best supplied as organic matter which improves the tilth and also renders mineral plant nutrients available. Considerable phosphorus and potassium are also carried in farm manure, our best supply of organic matter.

There are, however, five rather common soil conditions in the arid West that are decidedly unfavorable to potato production: (1) compact soils, (2) alkali, (3) waterlogging, (4) extraordinarily large supplies of organic matter, and (5) very coarse sands or gravels.

**Compact soils** cause a dwarfed vine growth. The total yield is likely to be low, and the tubers are likely to be small or knobby and irregular. Clayey and other compact soils are not porous enough to permit easy aëration. If conditions are favorable, such soils are likely to be over-wet and sticky in spring and hard and dry in late summer and autmun when the tubers should grow most rapidly. Both stickiness and compactness are undesirable: wet, sticky soils do not warm up soon enough, whereas hard soils do not allow the free access of air either to roots or to soil bacteria. Moreover, they are likely to crack and thereby to expose the soil moisture to rapid loss by evaporation. Finally, it is difficult to maintain the moisture supply, since great compactness in a soil both reduces its water-holding capacity and also causes additional water to be absorbed but slowly. Rapid rains are likely to run off and irrigation water either to be wasted or to be applied in sufficient quantity only at the upper end of the field.

**Alkali** injures potatoes markedly. Where only traces are present in the soil, the vines are slightly stunted. Larger quantities materially reduce both the growth of vines and the yield of tubers. When alkali salts are extremely abundant, germination is poor and growth is greatly retarded.

**Waterlogging,** even when unaccompanied by alkali, is disastrous to potatoes. If alkali be present as well, the prospect for a good yield is decidedly poor. Waterlogging shuts out air, prevents early warming up of the soil, and is likely to be fatal to the helpful soil bacteria. Cultivation and harvesting will also be difficult and expensive, partly because such soils are likely to become compact in late summer or because of stickiness in the soil due to excessive moisture.

**Excessive quantities of organic matter** stimulate rank vine growth. This reduces the size of the tubers and also encourages disease. Thrifty vines are necessary to high yield but they ought not to be so rank that they will not stand well out of the water furrow, at least while young. Air and sunshine both aid in preventing disease and in encouraging starch production. Moderate quantities of well-decayed organic matter, however, are necessary to maintain a uniform supply of soil moisture.

**Coarse sands and gravels** are so porous that it is difficult to maintain the uniform moisture supply essential to high yields of potatoes. Even small quantities of water pass quickly thru these sieve-like soils and percolate beyond reach of the roots. The temperature of such soils becomes high in the daytime on account of the high mineral content and because little water is present. Such soils encourage early maturity which counts against large yields. High temperature is also liable to weaken the vitality of the tuber buds, or eyes. It is practically impossible to get enough moisture-retaining material into such soils to make them good for potatoes unless they be treated more as mechanical mediums to hold plant nutrients and organic matter than as productive soils. Only trucking systems and nearby city markets can make this kind of potato-farming economically profitable.

It is apparent, then, that loamy soils are most desirable for potatoes. Such soils, while both productive and retentive of moisture, are at the same time warm in spring and porous enough to permit aëration and drainage. Cultivation and irrigation are not too difficult, and harvesting can be done without excessive labor. Clay loams, sandy loams, and even fine gravelly loams may be used. A wide range of soils—most of our good soils—are adapted to potato production. Care, however, must be exercised not to employ either the extremely compact types or the extremely porous types. If gravelly or coarse sandy loams are used, their content of organic matter must be maintained so as to provide a moderate and uniform moisture supply. If clays or heavy clay loams are used, careful manuring and judicious cultivation must not be neglected even for one season. The puddling of such soils is fatal not only to the yield but also to the smoothness of the tubers.

## SUPPLY OF ORGANIC MATTER

Manuring practices vary considerably. In the East commercial fertilizers are in general use, especially in the trucking areas. Phosphorus, potash, and nitrogen are frequently applied. This form of manuring has not yet become general in the West. Potato growers of Utah and adjacent states depend on farm manures and sod both for the organic matter and for the fertilizing elements. Occasionally a late fall or an early spring growth of alfalfa is turned under, but the usual practice is to make hay of this and return to the land the manure made by the animals. With many cattle on the summer ranges, this is probably the most profitable system of fertilizing the land.

**The chief function of farm manure and of sod** is to supply organic matter. In the end, complete decomposition results and the fertilizing elements are added to the soil in a readily available form. Important as the fertilizing elements may be, the indirect effect is still more important. Coarse manure and large roots are hindrances to cultivation and irrigation, but under favorable conditions, these soon decompose into fine particles that mix readily with the soil particles. Organic matter in such condition is valuable in two distinct ways: (1) by increasing the water-holding capacity, and (2) by creating a condition of medium porosity in the soil.

**Increases Water-holding Capacity.**—Decaying organic matter absorbs water much as does a sponge. Because many of the particles are hollow, the surface to which films of water can cling is much greater than on solid particles of the same volume. In addition organic matter contains a substance called humic acid which has the power of holding many times its own weight of water.

**Controls Porosity and Aëration.**—Organic matter also loosens clay soils and renders them porous. It has the opposite effect on coarse sands and otherwise extremely porous soils, in which it serves as sort of binder as well as a retainer of water.

It is common knowledge that wet sand, even if nearly pure and very coarse, will hold together with greater tenacity than the same sand when deprived of its moisture. Organic matter therefore consolidates loose soils both by supplying a binding agent and by furnishing a retainer of water. A high degree of looseness in clays and a high degree of consolidation in sands increase the water-holding powers of such soils. These conditions also encourage a more desirable aëration and a great uniformity of temperature.

Compact clays have too little pore space to hold much water or to permit the easy exchange of gases between the soil and the atmosphere. Roots and bacteria both need air; oxygen also helps in rendering mineral plant nutrients soluble. Sandy soils are likely to be too hot and clayey soils too cold. Extra moisture and consolidation of sandy soils moderate the temperature of these soils and thereby decrease evaporation. In heavy soils the increase of pore space encourages a more thoro ventilation. As the water content increases to about medium, the pore space increases. If more water is added the volume decreases and consequently the air space. It is at this point of greatest volume that soils aërate most readily and consequently maintain the most uniform temperatures. Roots can penetrate a soil in this condition more easily and more deeply because air is available at greater depths and because there is less resistance. In all respects the soil is then in the most favorable condition for plant growth. When such a desirable soil condition is reached, it is said to hold an optimum (Latin, meaning "the best") water content. Actively decaying organic matter tends to bring all soils into this desirable condition.

## SOIL MOISTURE

The quantity of moisture in a soil at planting time depends largely on the amount and on the distribution of rainfall, on the nature of the soil, on the previous crop in the rotation, and on the manuring practice. Preparation of the seedbed and subsequent cultivation likewise have considerable influence. Fall plowing permits the more ready absorption of winter and spring rainfall. Spring disking, harrowing, and weed control preserve the moisture for use by the crop. After the crop has begun growth, it is merely a question of time until the available supply in the soil becomes exhausted, or so nearly so as to prevent thrifty and rapid growth. Irrigation, which then becomes necessary, is discussed under a separate heading. If possible, the seedbed should contain enough moisture to germinate the seed sets and to give the young plants a good start.

## SEED SELECTION

Since some varieties of potatoes have much higher yielding possibilities than others, the variety chosen is important. One disturbing factor in choosing potato seed is that some districts cannot use home-grown seed. The North ships to the South practically all the seed used there. Arizona also imports seed potatoes. In the West, some growers have small farms in mountain valleys which furnish seed for their large farms in lower valleys, but in most cases selected home-grown seed is the best.

Sometimes varieties deteriorate, or "run out". For late-crop potatoes and possibly for early varieties also, this need not happen in Utah, if proper selection is practiced. There is a tendency to use or sell all the marketable potatoes, thus leaving the small ones for seed. Potato hills vary widely not only in the number of potatoes they produce but also in the kind. Some hills have from four to eight tubers of much the same size and shape, containing no extremely large ones and no small ones; others contain one enormous potato and a number of small ones; still others consist almost entirely of small tubers. Since both very large and very small potatoes are undesirable for market purposes hills with a fair number of medium-sized tubers are most desirable.

A set from any potato in the hill tends to produce a hill like the parent hill. A big potato from a poor hill is not as good as a small one from a good hill. It seems that any potato in a hill is likely to be as good for seed as any other. If such is true there is no objection to using the small potatoes from desirable hills if they are known to be such. It is bad practice, however, to use small potatoes from the cellar or from the grading machine because most of them are from undesirable hills.

## DISEASE CONTROL

Disease control is closely related to the selection and to the treatment of seed. It is also closely related to the cropping system because most of the diseases troublesome to potatoes live in the soil for four or five years, possibly for a longer time. Potatoes ought not therefore to be planted on the same land oftener than once in five years unless the necessity for doing so is really great. Greeley, Colorado, once famous for potatoes, nearly abandoned the crop for several years following 1911 because of disaster due to constant cropping. The crop is again increasing but is now being grown under much more careful cultural and rotation practices. Moderate irrigation, fall plowing, and wise manuring also aid considerably in the control of potato diseases. Under another heading are described the troublesome potato diseases occurring in Utah. Resulting damage and control measures are also there given.

## PREPARATION OF THE SEEDBED

**Preparation for Irrigation.**—Long before the plowing season approaches, land should be prepared for irrigation. This is not as simple as it may seem. In the first place head-ditches for delivering the water and the necessary distributing ditches leading out from these must be made. Since potatoes will, in practically all cases, be irrigated by the furrow system, it is necessary to determine first the direction in which water is to run. Ordinarily this problem is sadly neglected. Many of our farm lands slope in two or more directions: straight down the field from end to end, straight across from side to side, and at various diagonals. Since potato roots offer little resistance to washing, the slope ought not to be very steep. Badly rutted furrows permit rapid evaporation and also render both cultivation and harvesting inconvenient. Besides, such a practice is also responsible for the carrying away of the finest particles which are either organic matter or the soil particles richest in plant nutrients. Neither must the slope be too gentle, for this will encourage flooding across from one furrow to another, thereby leaving the ground too wet for potatoes.

Sometimes the land is naturally uneven or has been made so by silt deposits near the inlet head-ditches on alfalfa or other fields that have been cropped for a long period without plowing. Erosion channels and "dead" furrows too often give an uneven surface in many of the best fields. The wise plowing of "double" furrows, the proper dragging after plowing, and the judicious location of distributing head-ditches will usually overcome slight irregularities of surface. If, however, the land is badly roughened, it is highly profitable to level with plow and scraper before plowing. This not only saves labor in irrigation but enables the irrigator to distribute water evenly, thereby increasing the efficiency of both land and water. After any considerable filling of low places, enough time should elapse before plowing to allow the loose earth to settle to its permanent level. This avoids low places that will form pools during irrigation.

**Manuring.**—Farm manure for potatoes may be applied to a previous crop such as corn, beets, or garden stuff. It may be added as a thin coating after peas or on alfalfa or grass sod previous to breaking. Another practice that is gaining favor among successful growers is the fall or winter application of manure on fall-plowed land. Turning under in the fall is preferred, but to leave the manure on the plowed ground all winter to be worked into the soil in spring with a disk is also counted satisfactory. If the land is not fall plowed, it is still good practice to apply the manure in the fall or during the winter, even on top of snow. Unless the land is steep and compact, so badly eroded as to form channels, or frozen under the snow there will be little loss from the carrying away of manure in the spring run-off. Land manured in this way is best plowed as early as possible in spring.

If for any reason fall or winter application is not made, the manure should be added at the earliest possible time in spring. It is also advisable not to use manure containing much coarse straw or cornstalks for spring applications unless no other manure is available. The turning under of coarse manure at the same time that the potatoes are planted is still more uncertain, especially should a dry period follow planting. Poor stands and delayed growth are likely to result. Besides, potato scab is encouraged by an abundance of coarse manure. Finally, irrigation and cultivation are more difficult than when the manure is sufficiently decomposed to be readily incorporated with the soil particles.

**Moderate quantities of manure** have given better results for ordinary potato crops than either very light or extremely heavy applications. Truck farms sometimes apply 40 to 60 tons of fresh manure to the acre, but 15 or 20 tons is likely to be more satisfactory for general farming. The manure should be scattered over the land at the time it is being hauled out and spread as uniformly as possible. In these respects, manure spreaders are more efficient than hand labor. Making small piles to be scattered at another operation is wasteful of labor. Since this practice prevents uniform distribution, it is also wasteful of manure. Much of the fertilizing elements is leached into the soil directly beneath the pile, leaving only the resistant remnant to be scattered, especially if these piles are left for any great length of time. Horse and sheep manures deteriorate more rapidly in piles than do cattle and hog manures.

**Breaking**—For potatoes following alfalfa, the land should be broken in the fall to permit settling and to allow time for partial decomposition of the coarse roots. The practice of crowning is gaining favor. This consists of plowing to the depth of three or four inches to cut off the roots just below the crowns. When these crowns are thoroly dry, the plowing is done at the depth desired. Adherents of this practice maintain that fewer of the roots begin growth to cause trouble in intertillage the next season. Frequently, crowning is done in the fall and plowing early the next spring. Where breaking cannot be done until spring, it needs to be done thoroly and just as early as the soil condition permits. It may also be necessary to use compacting implements to conserve moisture and to promote decay.

**Plowing** should take place in the fall unless this is markedly inconvenient. With a late-planted crop such as potatoes it is easy to neglect fall plowing even when other work is not crowding. With potatoes this should not be allowed to happen except under unusual circumstances. If for any reason plowing is to be left until spring, it is advisable in the fall to work stubble and other residues into the soil with a disk. This is also a good practice when manure is applied in autumn and is not to be turned under until spring.

Plowing like manuring is best done early whether in fall or in spring. In few cases should potatoes be planted immediately after plowing. Poor stands are likely to result unless enough time is allowed for the soil to settle into a firm seedbed. Eight or ten inches is probably the best depth to plow. Shallower plowing often fails completely to cover manure or plant residues, whereas deeper plowing is likely to be too expensive in both time and horse labor.

Fall-plowed land, except where the blowing of the soil is troublesome in winter, should be left rough without harrowing or dragging of any sort. This gives the frost a chance at the clods, the insects, and the plant diseases. Fall, winter, and early spring rainfall can also pass at once into the subsoil, there to be stored for the growing season. Because fall-plowed land will settle enough during winter, it is not necessary to use packing implements such as the disk or culti-packer unless this is desirable for some other reason. As soon as the land dries enough to bear the horses in spring, the harrow or disk should be used to smooth and to mulch the surface.

**Harrowing.**—To get the best results from spring plowing not only must it be early, but it should be followed each half day with a spiketooth harrow or with an equivalent implement. If the land is cloddy or if much coarse organic matter is turned under, it may be wise to use the disk or the culti-packer to pulverize clods and to firm the sub-surface in order to promote decay.

Other harrowings may take place advantageously. These will break up any crust that might form and will mulch the surface besides further firming the seedbed beneath and pulling out weed seedlings before they can become established. This is the most economical time to kill weeds because wide implements may be used and because the weed seedlings are killed by only a slight scratching. Should the soil be badly infested with weed seed, this cultivation will bring them to the surface where they can germinate and be killed by the next cultivation. If the seedbed contains many weed seedlings when the time for planting has come, a final harrowing should precede the planter. In spite of all that can be done weeds sometimes get too large for the spiketooth harrow. The springtooth or disk harrow must then be used. The farmers of the Pacific Northwest use a rod weeder. This is merely a rod about an inch in diameter fastened on wheels in such a way that it can be let below the surface. The machine has cogs to give the rod a rotary movement, which prevents clogging due to weeds catching on the rod. It is particularly well adapted for clearing fallow land of weeds.

## VARIETIES

Varietal names of potatoes are in a muddle. Several hundred names occur in the country, but there are by no means that many varieties. Many names are often attached to the same variety and the same name to several varieties. In the intermountain region, for example, Burbank potatoes have been found bearing the names Burbank, Russet Burbank, Russet, Netted Gem, Brown Beauty. Doubtless there are many other names for this variety, but this list serves to illustrate the unfortunate condition. Names are easily forgotten and just as easily added. It is easy to name a potato from a successful grower, from a locality, or from some striking character, such as the netted or russet character in the Russet Burbank. Seedsmen often find it to their advantage to rename an old variety.

William Stuart, potato specialist for the United States Department of Agriculture, found that all the varieties grown in the United States might be put into twelve groups, or composite varieties. These groups are distinct, but further classification within the group was found to be not only difficult and uncertain but not particularly valuable, since each group is essentially alike. These so-called varieties may be regarded merely as strains of the real parent variety, the group. The twelve groups are: (1) Cobbler, (2) Triumph, (3) Early Michigan, (4) Rose, (5) Early Ohio, (6) Hebron, (7) Burbank, (8) Green Mountain, (9) Rural, (10) Pearl, (11) Peachblow, and (12) Up-to-date. Of these twelve, Utah grows eight but only five in considerable quantities. These five are Early Ohio, Cobbler, Burbank, Rural, and Green Mountain. A few Triumph and a few Pearl potatoes are grown. Rarely some Rose potatoes are seen.

The Rural group is at present the most important, altho the Burbanks are gaining rapidly in some sections. Rurals are grown all over the state for the late crop. Many names occur, some of the most common of which are Mortgage Lifter, Majestic, Rural New Yorker, Eureka, Freeman, and Rural. These varieties are flat-oval and have whitish russet-colored skins and yellowish-white flesh. When they begin to grow, the sprouts have a splash of blue or purple. The flowers also have a bluish tinge.

Burbanks are readily detected by their characteristic long shape and deeply russeted skin. They have compound eyes which under unfavorable conditions tend to develop into knobs. The common names under which this variety occurs are Burbank, Russet Burbank, and Netted Gem. Well-shaped Burbanks are perhaps the most popular market potatoes. For the last several years on many local markets they have brought slightly higher prices than other varieties. Their deep russet color and good cooking qualities are partly responsible for this bonus. The flowers are white.

Green Mountain potatoes greatly resemble Rurals. The color of skin and flesh is the same, but the sprouts, flowers, and stems of Green Mountain bear no splashes of blue or purple. Green, yellow, light brown, and white are the only colors occurring in any part of the plant or tuber. Because of this lack of blue, they are often called "white sprout" potatoes to distinguish them from the "blue sprout" Rurals. Whether the blue has anything to do with it is not known, but the Rural is considerably more heat-resistant than is the Green Mountain. A few splendid fields of Green Mountain potatoes are grown in the state but usually in high valleys or in localities cool for some other reason. It occurs as Beauty, Majestic, Queen, Green Mountain, and Idaho Rural.

Early Ohio is one of the two principal early potatoes of the trucking areas. It is reddish, elliptical-round, and has compound eyes which tend to develop knobs when grown under unfavorable conditions. It is usually called by its right name, tho it is known as Red Willard in some localities. The flowers are white.

The Cobbler is white, deep-eyed, and tends to be cubical. It tends also to get coarse with an abundance of soil moisture and organic matter. It then becomes medium-late instead of early. Its flowers are white under most Utah conditions, tho in cooler valleys they may sometimes be faintly rose-colored.

Triumphs are round to cubical, early, and have a solid deep rose-colored (magenta) skin. The flowers are few in number, small, and light rose in color.

Pearls resemble Rurals except that the sprouts are faint lilac in color. The tubers tend to be coarser. Pearl, Peerless, and People's belong to the Pearl group. This variety is not nearly so popular as formerly, at least in districts where good strains of Rurals or Burbanks have been grown for any great length of time. Blue Victor, much prized in some parts of Utah for local use, is a blue-skinned Pearl potato.

Just which variety to grow must be decided by the individual farmers. For most Utah valleys of 4,500 feet elevation, or thereabouts, Rurals and Burbanks seem about equal for late potatoes. In the cooler parts the Green Mountain may be added. Early Ohio and Cobbler seem to be the most popular early potatoes, tho many Triumph fields are found. Cobbler has the advantage of white skin and somewhat higher yield, but is not quite so early. The important thing in choosing a variety seems to be to get a well-selected strain and to grow only one early and one late variety unless special markets require more. Early potatoes mature in about one hundred days and late ones in about 130 days. Early potatoes are often dug before maturity in order to take advantage of high prices.

A variety much grown in Utah thirty years ago is the Meshanock. It had bluish skin, blue markings in the flesh, many and deep eyes, and a tendency to become rough. It is now almost entirely replaced by more desirable market potatoes. Many farmers, however, grow a few rows for home use. They maintain that this variety has better cooking qualities than have other varieties, and that it is more resistant to disease. Experimental evidence on both these questions is lacking. Its color, roughness, and mediocre yield doomed it as a market potato, altho for home use it will probably persist for a long while in some districts. White Meshanock was similar save that it lacked the color.

## DISEASES

Each year Utah potato-growers suffer heavy losses due to potato diseases. Careful estimates place the loss for the state as a whole at about 22 per cent, or about $400,000 to $450,000 annually. The most destructive diseases are Rhizoctonia, Fusarium wilt, blackleg, and the diseases of degeneration (chiefly mosaic and leafroll). The estimated loss for each disease is: Rhizoctonia, 4 per cent or about $80,000; Fusarium wilt, 5 per cent or about $100,000; scab, less than one per cent; blackleg, one per cent or about $40,000; mosaic, 10 per cent, or about $200,000; and leafroll, 2 per cent, or about $80,000.

**FIG. 5.—Effect of treating potatoes with corrosive sublimate for Rhizoctonia. The rows of vigorous plants were treated; in the middle is a row planted with untreated seed, the plants of which were badly injured by the fungi. (Courtesy Dr. B. L. Richards).**

### DESCRIPTION

These diseases all attack the growing vines in the field. In addition, Fusarium and blackleg cause tuber rots which affect the potatoes in storage.

**Rhizoctonia** (caused by *Corticium vagum*) is a fungus that lives over in the soil and on the tuber as small specks. These specks vary in size from that of pin point to that of a kernel of corn. They look like spots of dry mud, but when dipped in water, instead of washing off they become jet black and remain fast. Under the microscope these specks prove to be threadlike mycelia of the fungus in a compact, dry mass.

The mycelial threads germinate about the time the potato sets sprout. They grow into long threadlike strands which wind

FIG. 6.—Right: normal, healthy plant; left: mosaic disease of potato. The diseased plant is dwarfed and the leaves are badly crinkled and the chlorophyll is damaged, causing spots of lighter green or yellow. (Courtesy Dr. B. L. Richards).

around the young stems and stolons and kill the softer tissues. If conditions are favorable to the disease early in the season, the stems are so badly injured as to be stunted or even killed outright. Many stolons are cut off, preventing the formation of tubers. In older plants, the inner tissues become too woody to be destroyed; consequently, only the softer outer tissues are killed. The tubes up which water of the potato plant goes from the roots are imbedded in the woody interior, whereas the tubes that carry food from the leaves where it is manufactured to the tubers where it is stored are in the outer soft tissues. Older plants injured with Rhizoctonia may look green and fresh, but the tubers do not grow rapidly because the food stream does not reach them. The vines have large quantities of extra starch that normally goes to the tuber for storage. Clusters of new leaves form in the axils of the normal leafstalks. This gives rise to the term "rosette" disease. Occasionally, small tubers form above ground on the vines. Growing in the light, these abnormal potatoes become green by developing chlorophyll. They are therefore valueless for food. The base of the main stem is in many cases covered with brown strands and is usually shriveled.

**Fusarium wilt** (caused by the fungus *Fusarium oxysporum*) is another disease causing as great if not greater loss than does

FIG. 7.—Leafroll disease of potatoes. The leaves become rather thick and leather-like and roll upward from the edges toward the midrib. (Courtesy Dr. B. L. Richards).

Rhizoctonia. It lives over in the soil and inside the tuber. A slice one-eighth of an inch in thickness cut from the stem end of the tuber shows its presence as brown or dark spots. When the sets sprout, the fungus begins to grow and, entering the water tubes of the stem and stolons, clogs them up. Bad attacks cause wilting even when the ground is moist. Whole fields of healthful-looking vines have wilted down, turned brown, and died inside of a week. More commonly, however, the plants wilt, turn brown by degrees, and become unthrifty, dying three or four weeks ahead of the time for normal maturity.

Yields are thereby decreased markedly; the cooking and keeping qualities of the potatoes are also impaired. Badly infected tubers will not meal up when mashed after cooking, as the fungus causes a hard, discolored mass. An accompanying relative of this fungus also causes "dry" rot which is a serious storage disease, spreading as it does rapidly thru the whole bin of potatoes.

**Common scab** (caused by the bacterium *Actinomyces chromogenus*) lives in the soil. On the tuber it is a scabby pit, from which it gets its name. Scabby potatoes are not injured for cooking except that extra waste is necessary in peeling. Yield is not materially affected, but badly scabbed tubers are so unsightly as to be unfit for market. Mechanical scratching or wounding of the tuber may also cause a scabby appearance.

**Blackleg or backstem rot** (caused by *Bacillus phytophorus*) is a bacterial disease that attacks the young vine and the tubers in the field. The stem is black from the set to two or three inches above ground. The plants are killed or dwarfed, the leaves have a tendency to roll about the midrib, and the whole plant looks upright and scrubby. The tuber is likely to show dark spots or interior areas of soft rot that are black and foul-smelling. The disease spreads rapidly by means of infected seed and possibly by means of cultivating machinery and of irrigation water.

**Diseases of degeneration,** chief of which are *leafroll* and *mosaic,* have during the last few years caused heavy losses in the potato crop of Utah. No organism has yet been isolated as the specific cause of any of these diseases. It is known, nevertheless, that the transfusion of juice from crushed leaves or the contact of a freshly cut tuber set from a healthy tuber with a set from a diseased tuber produces the disease in the plant grown from the healthy set. In the field, insects (especially aphids) carry the disease from a diseased to a healthy plant. During the first season of infection, the leaves will show characteristic crinkling and mottling of mosaic or the definite rolling of leafroll, but the yield may not be seriously affected. During the second season or at least by the third season the whole progeny of the infected stock degenerates. The leaves mottle and curl and the vines die early, thereby reducing the yield in many cases to below 20 or 30 per cent of what might be expected from healthy plants. In bad attacks no tubers at all may be produced. In ordinary attacks the tubers are greatly decreased in size and in number.

Since these diseases are tuber-borne, it is necessary to avoid infection in every possible way and not to use seed stock known to be infected. The most feasible method of accomplishing these results is to dig hills separately, and select the high-yielding ones that consist principally of uniform marketable tubers. The next season these are grown in a seed plot isolated from other fields and as soon as any plants show mottling or crinkling, these are pulled entirely so as to protect the other plants from contamination.

"Running out" of strains or varieties is due largely to one or more of these diseases of degeneration. As pointed out under the section on "Improving the Crop", hill selection and rogueing in Cache Valley have with Rural potatoes kept head of these diseases.

CONTROL MEASURES

**Rotation of crops** is necessary because Rhizocotonia, Fusarium, and scab live four or five years in the soil. Other plants assist in carrying them along from year to year. Rhizoctonia lives on redroot pigweed, ground cherry, Russian thistle, sugarbeets, and some other plants. Clean cultivation and thoro rotation are therefore necessary in combating these diseases and scab. It is probable that even where only one crop of potatoes is grown on the same land in five to six years, the result is merely greatly to decrease the number of organisms in the soil without actually annihilating them. The next season after potatoes, the soil probably teems with the disease organisms, but each year thereafter they get fewer and fewer until in five or six years they are at a low enough ebb to make another crop safe even in an unfavorable season. Some workers think that virgin soils carry Rhizocotonia organisms. If so, they are not in numbers great enough to destroy the first crop of potatoes.

**Seed selection** must also be practiced to avoid the planting of infested seed. Fusarium can be detected by cutting a thin slice (1/8 inch thick) from the stem end. Any tubers showing brown or dark spots should not be used for seed. Badly scabbed tubers should also be discarded, as should tubers with many specks of Rhizocotonia, especially if these specks are larger than a half wheat kernel. Leniency with disease in choosing potatoes for seed is likely to be as short-sighted as half-heartedness in quarantining for scarlet fever. The pulling out and burning of diseased plants may help in disease control.

**Treatment with chemicals,** if wisely used, may be of considerable assistance in controlling disease. Either of two treatments may be used: (1) corrosive sublimate or (2) formalin. Seed potatoes should be treated before they have started to sprout. Sometimes vitality is decreased when treatment is applied after growth is well begun.

*Corrosive sublimate* is more effective but is considerably more expensive than formalin. Four ounces of the sublimate powder ($HgCl_2$) is dissolved in thirty gallons of water. *After being selected,* but before being cut into sets, the tubers should be soaked for 1½ hours in the solution. Because it corrodes metal, wooden vessels must be used for this treatment. The solution becomes weaker during treatment by part of the sublimate's uniting with the protein of the potato. Not more than four lots of potatoes should be treated in the same solution. Sacks and dirt should not be immersed because they absorb great quantities of the sublimate, thereby decreasing its strength still more rapidly.

**CAUTION:**—Corrosive sublimate is **deadly poison to man and beast.** Discarded solutions are best poured in holes and covered with at least two feet of earth. It is not injurious to the hands unless open wounds are brought in contact with it.

*The formalin treatment* is administered in the same way except that wooden vessels are not required. The solution is made by adding a pint of commercial formalin (40 per cent) to thirty gallons of water. Old formalin loses strength if left exposed to the atmosphere; hence, sealed cans are safest. If they cannot be obtained, inquiry should be made as to freshness and strength. The potatoes should be allowed to soak two hours. Any number of lots of potatoes may be treated without impairing its strength. Animals or persons will be sick if they drink the solution, but it is not so deadly as corrosive sublimate. Tho cold formalin is not nearly so good as corrosive sublimate, hot formalin is thot by some pathologists to be nearly as good.

**Thrifty growth** greatly helps potato plants in overcoming light attacks of these diseases. On this account every precaution should be taken to promote vigorous growth. Good seedbeds, moderate irrigation, and timely, clean cultivation encourage rapid, healthful growth. The effects of early blight, tipburn, and other minor diseases are largely offset by such favorable conditions. Spraying the vines is practiced in the East and Middlewest for early blight, tipburn, and late blight (the worst of all potato diseases, but one that has not yet caused trouble in the arid West), but these diseases are not yet serious enough in Utah to warrant spraying.

## SEED CONSIDERATIONS

**Imported seed stock** for early varieties is brought into Boxelder, Weber, Davis, and Salt Lake Counties in increasingly large proportions every year. Some growers import all their seed stock, but usually only a part is brought in and this is put in separate plats for seed stock the following season. Thruout Utah are valleys fully as favorable as the Red River region of Minnesota, from whence comes most of the imported seed. It is known that except in a few really unfavorable districts late varieties can be maintained. Many of our best trained agriculturists feel that even early strains could be maintained if it were seriously undertaken. As yet no real attempt, either from the standpoint of proper cultural methods or from that of adequate community action, has yet been made. There is promise both of commercial and of agricultural success were such a project properly prosecuted.

**Tuber selection** of some sort is essential when home-grown stock is used for seed. Selection by the hill method the previous autumn is best. Lacking this, the grower will find it profitable to select from his cellar bin. Because of hereditary characters, good marketable tubers are safest. The tendency to use culls for seed because they are unmarketable is bad practice, since most of the culls come from poor hills. Gilmore[1] reports that in a crop having 18 per cent culls, 76 per cent of these came from weak or unproductive hills. The use of rough or otherwise undesirable tubers for seed will produce a higher percentage of potatoes poor in the same respect than will the use of good tubers. The practice of choosing for seed the poorest hills plus a few of the poorest potatoes from the good hills appears to be little short of folly. The poorest-trained animal breeder in the country would not consider for a moment the selection of the poorest animals for parent stock.

**Sprouting** is a new but growing practice in parts of the East. With the seed selected by the best method in keeping with his circumstances, the farmer may find it wise to prepare for cutting by sprouting, or "greening", his seed. This consists in exposing the potatoes to diffused light for two or three weeks, after the tubers are treated chemically but before they are cut. Short, green, tough shoots begin growth. These do not get long as do those sprouts which develop in dark storage places that are too warm. Sprouting in the dark is detrimental because the sprouts must be broken off, thereby causing extra labor besides depleting the tuber of just so much food for the plant when it does begin growth. The short green sprouts, however, are not broken off. Growth following such treatment begins much sooner, especially if the ground is somewhat too cool or too wet at planting time. Sprouting enables the grower to detect and to discard tubers with dormant buds and with concealed interior rot. Better stands and consequently higher yields are therefore thot to be obtained, tho in Colorado little gain was secured on late-crop potatoes.

**The size of seed piece** for planting has received attention in all parts of the country. Some farmers prefer whole tubers for seed, others half tubers, and still others cut pieces—"sets" they are called—varying in size from one-half ounce to several ounces. A few growers plant a crop late in the season so as to have small, immature, whole seed for the next season's planting, but usually cut pieces are used. Blocky sets about two ounces in size with one or two vigorous eyes in each set seem to be best.

[1]California Experiment Station Circular 161, p. 2.

Tables III, IV, and V (showing results from Canada, Idaho, and Utah) indicate that 2-ounce seed pieces produce greater net yields of marketable potatoes than either larger or smaller pieces.

TABLE III.*—The Influence of Size of Potato Set on Yield in Ontario, Canada

| Size of Set (oz.) | No. Eyes in Each Set | Seed to Acre (bushels) | Per Cent Marketable | Marketable (bushels) | Total (bushels) | Total less Seed (bushels) | Marketable less Seed (bushels) |
|---|---|---|---|---|---|---|---|
| 1/16 | 1 | 1.3 | 61.0 | 36.8 | 47.5 | 46.2 | 35.5 |
| 1/8 | 1 | 2.6 | 88.6 | 78.8 | 89.7 | 87.1 | 76.2 |
| 1/4 | 1 | 5.2 | 89.7 | 98.4 | 111.1 | 105.9 | 93.2 |
| 1/2 | 1 | 10.3 | 88.7 | 109.4 | 129.0 | 118.7 | 99.1 |
| 1 | 1 | 20.6 | 89.5 | 129.9 | 148.4 | 127.8 | 109.3 |
| 2 | 1 | 41.2 | 87.6 | 149.7 | 173.9 | 132.7 | 108.5 |

*Ontario Sta. Bulletin 238, p. 43.

In Table III Zavitz reports tests on sets 1/16, ⅛, ¼, ½, 1, and 2 ounces in size. Total, marketable, and net yields increased with the size of seed up to one ounce which yields practically the same as 2-ounce sets. In Table IV are given results and computations from results obtained by Aicher at Aberdeen, Idaho. His results show an increase in total yield from the largest sets, but the quantity of seed used is so large and the percentage of culls is so high for the large pieces and for the whole tubers that 1-ounce sets gave the highest net yields, that is, the marketable yield minus the seed used.

TABLE IV.*—The Yield from Planting Whole, Halves, and Quarters of Potato Tubers which Weighed 8, 4, and 3 ounces. (1913-1916) (Idaho)

| Size of Tuber and Set | Stalks to the Hill | Per cent Marketable | Acre-Yield: Total (bushels) | Acre-Yield: Marketable (bushels) | Acre-Yield: Seed Planted (bushels) | Acre-Yield: Net: Marketable less Seed (bushels) |
|---|---|---|---|---|---|---|
| 8-oz. whole........ | 8.67 | 52.6 | 392.9 | 200.6 | 96 | 104.6 |
| 8-oz. halved...... | 4.71 | 65.2 | 333.5 | 210.5 | 48 | 162.5 |
| 8-oz. quartered | 2.63 | 69.1 | 314.0 | 218.2 | 24 | 194.2 |
| 4-oz. whole........ | 5.41 | 46.3 | 368.7 | 171.0 | 48 | 123.0 |
| 4-oz. halved...... | 2.98 | 66.1 | 332.9 | 220.1 | 24 | 196.1 |
| 4-oz. quartered | 1.71 | 77.4 | 322.7 | 250.9 | 12 | 238.9 |
| 3-oz. whole........ | 4.82 | 54.2 | 361.7 | 201.1 | 36 | 165.1 |
| 3-oz. halved...... | 2.64 | 68.8 | 355.5 | 253.8 | 18 | 235.8 |
| 3-oz. quartered | 1.72 | 78.0 | 262.7 | 201.5 | 9 | 192.5 |

*Jour. Amer. Soc. Agron., Vol. 9, No. 5, p. 221.

A similar test now being conducted at Logan, Utah, has so far given similar results, that is, sets weighing about 2 ounces with two or three good eyes on each set have given higher yields than either larger or smaller sets. It is interesting that sets from 8-ounce tubers gave systematically higher yields than sets of the same weight or than sets representing the same fraction of 4-ounce tubers. These results are clearly shown in Table V.

TABLE V.—Effect of Size of Seed-piece and Size of Tuber Before Cutting on the Total, Marketable, and Net Yield of Potatoes (Logan, Utah) 1924

| Size of Tuber and Seed-piece | Acre-yields Total (bushels) | Marketable (bushels) | Seed Planted per Acre (bushels) | Net Yield (bushels) |
|---|---|---|---|---|
| 8-oz. whole | 653.4 | 500.0 | 120 | 380.0 |
| 8-oz. half | 549.7 | 475.0 | 60 | 415.0 |
| 8-oz. quarter | 551.8 | 487.5 | 30 | 457.5 |
| 8-oz. eighth | 467.6 | 435.5 | 15 | 420.5 |
| 4-oz. whole | 408.3 | 379.7 | 60 | 319.7 |
| 4-oz. half | 454.3 | 389.8 | 30 | 359.8 |
| 4-oz. quarter | 394.0 | 363.0 | 15 | 348.0 |

**Cutting** is best accomplished by hand. Machines cannot look for eyes and must be fed by hand. A stationary knife is much used in Colorado and other regions. It is somewhat faster and nearly as accurate as hand cutting. The operation of cutting is best begun at the stem end, that is, the end having the fewest eyes. If a thin slice was not taken off the stem end before treating, it should be done now and all tubers showing brown spots discarded. The knife used for cutting should be immersed in formalin for a few minutes after cutting an infested tuber. This necessitates the use of two or three knives for each cutter. Such practice is not a drawback, since the knives will keep sharper and thereby cause less weariness of fingers and wrists.

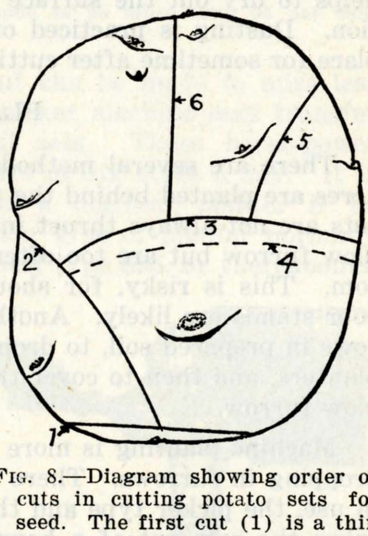


FIG. 8.—Diagram showing order of cuts in cutting potato sets for seed. The first cut (1) is a thin slice to show whether there is any Fusarium. Cut No. 4 is behind. Cutting should begin at end containing the fewer eyes and should finish by splitting the cluster at the opposite end of the tuber. The sets should be somewhat larger than a large egg and blocky.

After the thin slice is removed from the stem end of the tuber, the first set should also be taken from that end in such a way as to make a piece about the size of a hen's egg with one or two strong eyes in it. The succeeding sets should be cut after the same fashion until only enough tuber is left for two sets. The piece should then be split in such a way as to divide the cluster of eyes at the bud end of the tuber. This avoids so many eyes in one set as to produce several shoots and consequently a high percentage of small potatoes.

Cutting is best done on the same day as planting. Where this is impractical, it should not be more than a day or two before. This decreases danger of mold or of the drying out of the sets. Sacks in which sets are placed should be piled so as to permit thoro ventilation. These sacks should have been soaked in formalin to sterilize them. Corrosive sublimate is so deadly as to be dangerous for treating sacks. The sacks should be dried before being filled with sets.

Some growers sprinkle the cut sets with road dust, slaked lime, or powdered gypsum before planting. This, they think, helps to dry out the surface and therefore to prevent evaporation. Dusting is practiced only when planting is not to take place for sometime after cutting.

## PLANTING

There are several methods of planting potatoes. Too many acres are planted behind the plow that turns under manure; the sets are not always thrust into the loose soil on the side of the plow furrow but are too often dropped on the hard furrow bottom. This is risky, for should a dry period follow planting, poor stands are likely. Another and better way is to make furrows in prepared soil, to drop the potatoes by hand or by hand-planters, and then to cover them by dragging or with a shallow plow furrow.

Machine planting is more efficient than either plowing in or dropping in furrows. There are two kinds of machine planters in use, the picker type and the notched-wheel type. The picker takes the sets out of a hopper by means of spikes which are fastened to a revolving vertical disk and drops them down a pipe into the furrow. The other machine does the work by distributing the sets to a notched, revolving, horizontal disk which is watched by a man, who fills empty notches or removes a set if two get into one slot. When the notch passes over the delivery spout, the set drops thru. The picker machine requires only one operator, but misses from 5 to 20 per cent of the time, with an average failure of about 15 per cent. The notched-

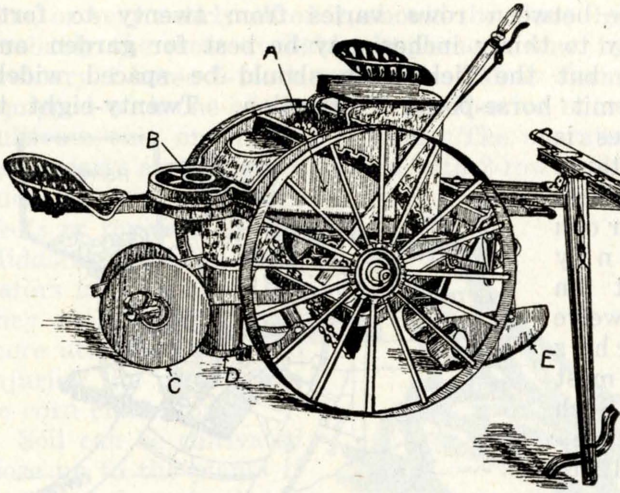



FIG. 9.—Notched-platform potato planter. A, hopper carrying sets; B, notched platform; E, furrow opener; D, drop spout; C, covering disks. Two operators do nearly perfect work, that is, almost no hills need to be missed. This machine can be made to be more than 95 per cent efficient.

wheel planter requires two men but can be made to miss less than 1 per cent of the hills. The picker machine may transfer disease from infested to healthful sets. These horse-power planters furrow, drop, and cover five or six acres a day. It is estimated that a farmer can afford a machine planter if he grows six acres or more. The picker type of planter normally costs about $70 and the notched-wheel type $85, or thereabouts.

There is no fixed depth for planting. From two to six inches is usual, while three to four is most common. Light, warm soils permit planting to the depth of five or six inches. Heavy soils require planting as shallow as possible without endangering the growing tubers to exposure from light, which injures them by causing chlorophyll to develop. In sands, four to six inches is better because it protects the tubers from excessive heat at the surface. Early potatoes are planted as soon as the soil becomes reasonably warm, and late ones usually in May, tho in some districts, early June is the best time.

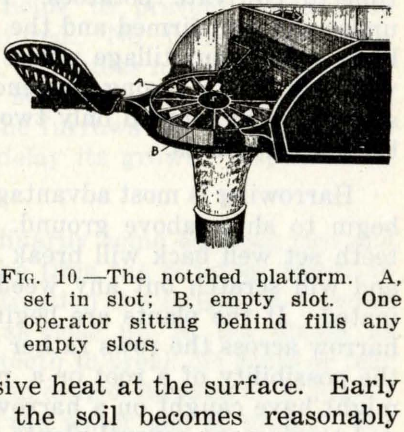



FIG. 10.—The notched platform. A, set in slot; B, empty slot. One operator sitting behind fills any empty slots.

The distance between rows varies from twenty to forty inches. Twenty to thirty inches may be best for garden and truck potatoes, but the field crop should be spaced widely enough to permit horse-power cultivation. Twenty-eight to thirty-six inches is a common distance between rows. Sets are planted from eight to twenty inches apart in the row; twelve to sixteen inches seem to be most satisfactory. Such planting requires about 12 to 24 bushels an acre for planting with 1- and 2-ounce sets, respectively. In Europe as much as 40 bushels of seed is often used with good results. On fertile soils, Utah farmers may find it more profitable to plant as close as ten or twelve inches in the row.

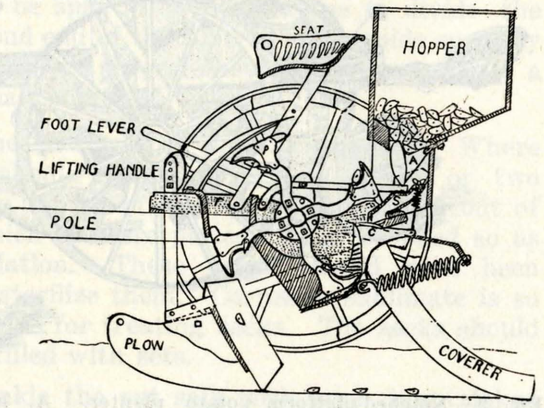


FIG. 11.—Diagram of a picker type of potato planter. P, picker arm; A, opening from hopper; S, spout to C where spring pushes set against spike of picker arm. Operated by one man but plants only about 85 per cent of the hills.

## CULTIVATION

While the seedbed is being prepared is the most effectual time to cultivate potatoes. Fine, mellow seedbeds with the under-soil well firmed and the surface well mulched demand but little subsequent tillage unless the land is somewhat foul with weeds or has a strong tendency to bake. Potatoes on good seedbeds will demand only two or three harrowings and two or three cultivations.

Harrowing is most advantageous just before the potato plants begin to show above ground. A spike-tooth harrow with the teeth set well back will break any crust that may have formed and will scratch out any weed seedlings that may have germinated. If the plants are beginning to show, it may be wise to harrow across the rows rather than with them in order to avoid the possibility of a root or a piece of undecayed manure that might have caught on a harrow tooth from running down a row and tearing out several plants in succession.

When areas of any considerable size are grown, all cultivation, or very nearly all of it, should be done by horse power. Probably the most available implement now in Utah is the ordinary 1-horse 5-tooth cultivator. Most farms are already equipped with one of these. It is effective but can be made to cultivate only one row at a time. The operator's time is not used nearly as efficiently as it is with 2-row or 4-row cultivators such as are used for beets or for corn in the Middlewest. Beet cultivators may be used, but they need a great deal more attention to avoid injuring the plants than do corn cultivators.

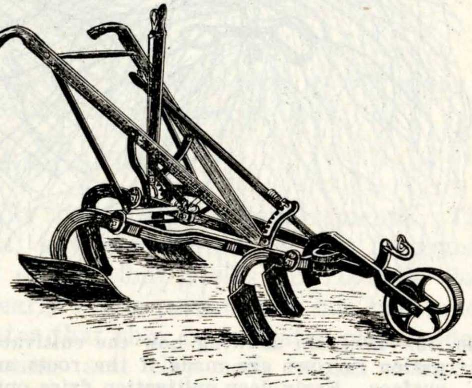


FIG. 12.—A one-horse, one-row cultivator.

Soil can be cultivated close up to the plants if the land is not cloddy and is not filled with undecayed rubbish and if the rows are straight. As soon as the potatoes are up far enough to permit the rows' being easily seen it is time for the first cultivation, or for a good harrowing if preferred. The first cultivation should be close up to plants and shallow near the row but considerably deeper near the middle where the irrigation furrow is to be made later. This dries out the top soil and encourages the roots to develop below the stirred soil. It is well therefore in the first cultivation to move all soil that is to be moved at any other cultivation or in the making of the furrow for irrigation. This helps to prevent roots from developing where they will be injured. No furrow, however, should be made at this cultivation. Potatoes naturally root near the surface unless this precaution is taken early in the season. The cutting of many roots when the furrows are made is almost sure to weaken the plant and to delay its growth just when it should be most vigorous.

The second cultivation will ordinarily come between two and four weeks later, that is, about the time the potatoes begin to show need for water. At this cultivation the irrigation furrows may be made and the soil stirred as close up to the plants as possible without allowing the side teeth to break off roots or tear out plants. There is no advantage in deeper furrows or in higher hilling than is necessary to carry the water and to protect the potatoes from sunlight. Excessive hilling exposes the soil to hot sun and to high evaporation. If there are many weeds showing

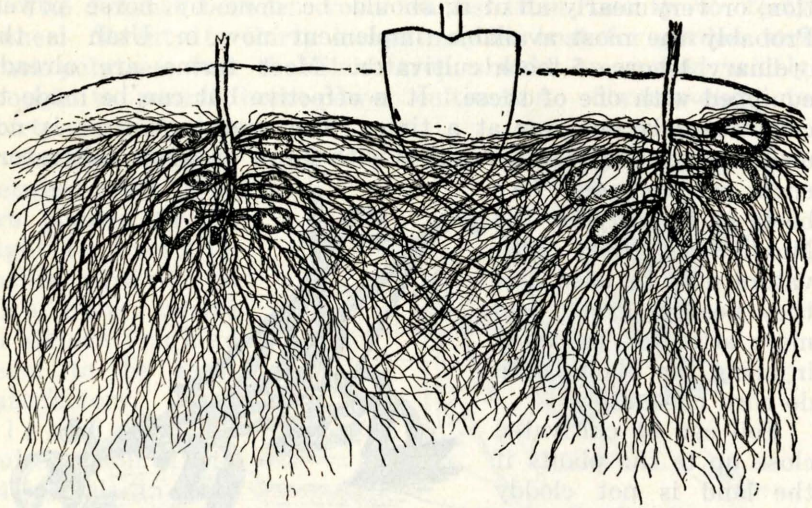


FIG. 13.—Diagram showing how the cultivator shovel cuts roots when irrigation furrows are made if the roots are allowed to develop near the surface. Early deep cultivation dries out the soil between the rows and causes the roots to develop deep enough in the soil to avoid being injured by later cultivations.

in the rows it may be wise to pull these by hand or to chop them out with a hoe. On the other hand, if there are but few weeds, it is not likely to pay to weed at a special operation, since a few scattering weeds may be pulled out during irrigation by the man tending the water, especially if he is using only a small stream and if the land is well laid off for irrigation.

Within a few days following the first irrigation a crust will have formed on most soils and many weeds will have germinated. This is the opportune time for the second or third cultivation, as the case may be, because the weeds are most easily killed while they are small and because any crust formed is broken before too much evaporation has taken place. On heavy land, care should be taken to have the furrows deep enough to prevent any flooding over the rows and thereby avoid baking around the growing tubers. The third cultivation should follow the second irrigation in the same way. This will be the last cultivation necessary, provided, of course, the land was not foul with weeds or there was no neglect in the preparation of the seedbed. In case of weedy land another cultivation and one or two thoro hand weedings may be required. Soon after the third cultivation the potatoes will begin to spread across the row. It is then too late to cultivate with horse-power machinery for the vines will be broken or trodden on.

All experiment stations where potatoes are a common crop advocate that cultivation be avoided while the plants are wet. There are two reasons for this. The first is that the stems and leaves are then more brittle on account of the turgidity due to an abundance of water in the cells of the plant. The second reason is that certain diseases are more readily spread by cultivation when small droplets of water are hanging on the leaves.

## INSECTS

Many insects attack potatoes, but none have as yet made it necessary to adopt special control measures in Utah.

## IRRIGATION

Potatoes are sensitive in their moisture requirements. Tho waterlogging is disastrous, extreme drouth is not favorable. Some varieties withstand drouth, but yields are usually low under such conditions. Nearly every person who has had much to do with potatoes advocates that they be irrigated only moderately heavily. The deep loams and clay soils which compose nearly all the best farming lands of Utah probably require only three or four irrigations. Porous sands and gravels will require four to eight lighter applications. The low water-holding capacity of these soils makes it imperative to apply water more frequently but in smaller quantities. From 15 to 20 inches is probably the right amount to apply during a season in most parts of Utah. Very gravelly soils may require more than eight applications, but if so, the applications should be still smaller and applied rapidly to insure uniform distribution.

The first application should come neither too early nor too late. It is too early if the plants will not suffer for some time and if irrigation will cool the ground excessively. It is well, however, to apply water before the plants wilt so badly that they take on a dark, unhealthy color and stop rapid growth. Farmers of some sections can get water whenever they wish it. These men will do well to irrigate potatoes as soon as the vines begin to take on a dark color and show signs of being wilted at other times than in the middle of the day.

Where the water goes from one farmer to the next in "turns", it is well to irrigate soon enough. Unless the season is a cold one, it is probably safer to irrigate a few days too early rather than a few days too late as the missing of a turn might necessitate. It may be wise on porous soils to irrigate every alternate row one turn and the other alternate rows or all of them the next turn, giving just enough the first time to make sure that there will be no retardation of growth. Both of the applications taken together would be counted as one complete irrigation. If the irrigation stream is rapidly decreasing in volume it may be wisdom to irrigate rather early, especially if the season is warm. The main thing to be accomplished is to avoid a retardation of growth due to a lack of moisture since this may materially decrease the yield.

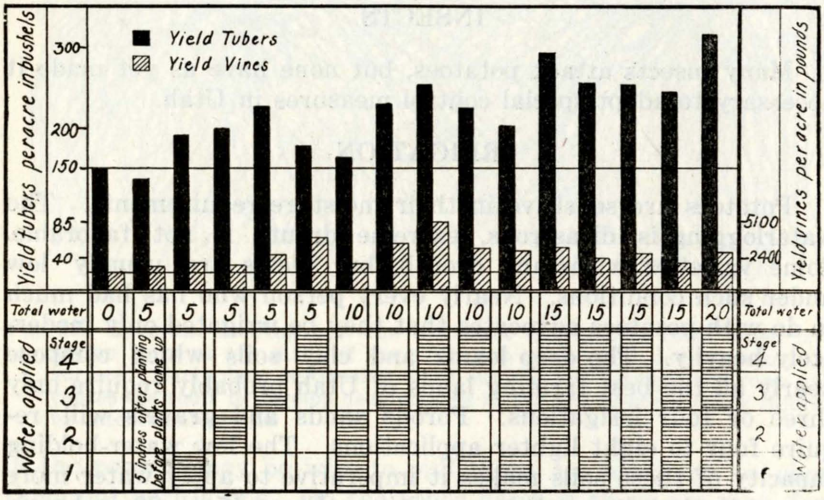



FIG. 14.—Diagram showing the effect of irrigation with varying amounts of water at various stages of plant growth. The five-year average acre-yield of tubers and of vines are both shown. The experiments were conducted on the Greenville Experimental Farm at Logan, Utah.

Considerable care should be exercised to get enough water to the plants at the lower end of the rows without over-irrigating those at the upper end. This is best brought about by running the rows in such a direction that there is enough slope for the water to run readily but not enough to cause much washing. A good head of water should be used and the head-ditches should be near enough to permit the water to run quickly to the bottom of the rows. On coarse sands, sandy loams, or otherwise porous soils, this is especially important. It is easy to run small streams down long furrows and shut them off as soon as the water reaches the lower end. This, however, distributes the water very unevenly, because the top is thoroly soaked—often wastefully so—before the lower end is scarcely more than wet in the furrow bottoms. It is good practice to start at one end of the field and work to the other, allowing the water that has passed thru the furrows of one "run" to pass into a few furrows on the one just below. This avoids wasting water.

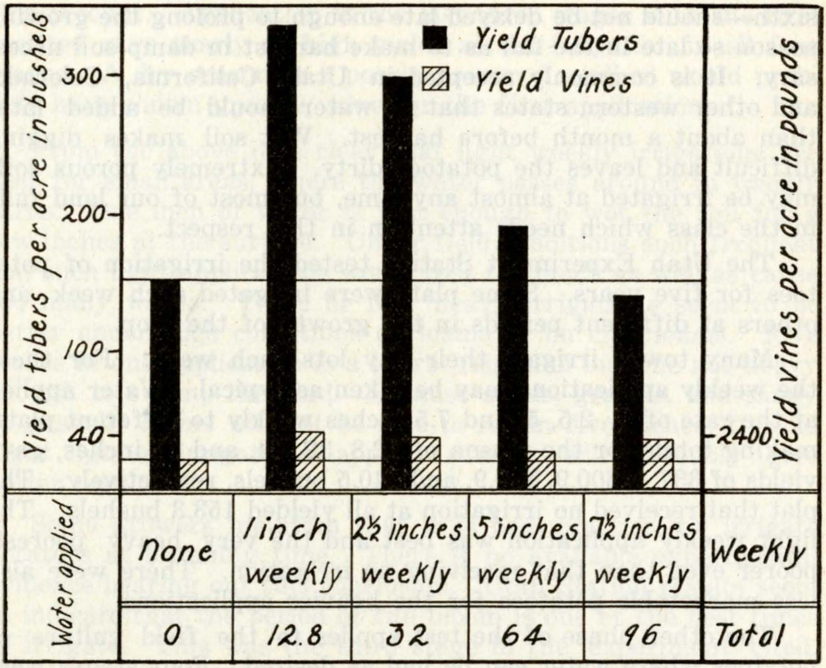



FIG. 15.—Five-year average acre-yield of potato tubers and vines on plats receiving different quantities of irrigation water each week.

In case the land is uneven, somewhat steep, or difficult for some other reason, it is often advisable to provide sod, or coarse manure if sod is unavailable, for helping to regulate the water in the furrows. A load of sod scattered along the head-ditches before irrigation is begun may save time and trouble. Small inlets for each eight to twelve furrows are of great assistance for controlling water on uneven or steep land. Sometimes it is also advisable to have a number of sharpened willows or pegs to help hold sod or weeds for turning a part of the stream into one of these inlets. Canvas dams are also convenient.

The time for the second irrigation will be somewhere near blooming time. The furrows have been stirred with the cultivator after the first irrigation, but the "regulation" of the furrows in the small inlet ditches should not have been disturbed, unless it is advisable to run water twice as far the second time. In this case every alternate head-ditch is cultivated across and the furrows made continuous. When the vines get long they hang into the furrows and render it difficult to run the water long distances. It may therefore be best to use short "runs" thruout the season. The last irrigation—whether the third or sixth—should not be delayed late enough to prolong the growing season so late in the fall as to make harvest in damp soil necessary. It is commonly accepted in Utah, California, Colorado, and other western states that no water should be added later than about a month before harvest. Wet soil makes digging difficult and leaves the potatoes dirty. Extremely porous soils may be irrigated at almost any time, but most of our land falls in the class which needs attention in this respect.

The Utah Experiment Station tested the irrigation of potatoes for five years. Some plats were irrigated each week and others at different periods in the growth of the crop.

Many towns irrigate their city lots each week. For these the weekly applications may be taken as typical. Water applied at the rate of 1, 2.5, 5, and 7.5 inches weekly to different plats, making totals for the season of 12.8, 32, 64, and 96 inches, gave yields of 337.1, 300.9, 190.9, and 140.5 bushels, respectively. The plat that received no irrigation at all yielded 153.3 bushels. The light weekly application was best and the very heavy poorest, poorer even than that receiving no irrigation. There were also less marketable potatoes for the heavier applications.

The other phase of the test applies to the field culture of potatoes where water can be had as desired. Four stages were arbitrarily chosen: (1) when the vines were four inches high, (2) when tubers began to form, (3) when plants were in full bloom, and (4) when the tubers were ripening. Another plat was irrigated after planting but before the plants showed above ground.

The irrigations were applications of five inches each. Four plats were irrigated only once; others received two irrigations of five inches each in different combinations of stages; others three; and one four, that is, in all four stages. The plat receiving a 5-inch irrigation in each stage and the one receiving it in the last three stages outyielded the others.

The yield with no irrigation was 153.3 bushels; for one 5-inch application the results were: after planting but before coming up, 139.0 bushels; first stage, 193.9 bushels; second, 201.4 bushels; third, 229.0 bushels; and fourth, 180.1 bushels. Omission of first stage when three applications were made gave 294.8 bushels, omission of the second 257.2 bushels, of the third 256.4 bushels, and of the fourth 246.4 bushels as against 317.1 bushels for application in all four stages, and 153.3 bushels for none. The high yield of the non-irrigated plat shows that abundant water was stored in the seedbed. These results are what might be expected on well-prepared soil of the same kind—a deep, fertile clay loam. The later irrigations seem more important on this account. Application in the last three stages with the first omitted gave nearly as high yields as did irrigation in all four stages. A dry season or a poorly prepared seedbed would probably have shown greater value for the first application.

From the above it is clear that light weekly irrigations are best for small areas, where the water passes around in weekly turns. One inch of water is just enough to wet the soil for a few inches at the surface. Under field conditions such frequent and such light applications would cost too much as well as cause too many weeds. Three or four heavy irrigations seem to be better under such conditions on loams or on clay loams. Five inches in one application is a thoro irrigation but one not heavy enough to swamp the land. Because sands, gravels, and sandy or gravelly loams will not be able to retain five inches, five to eight lighter irrigations applied oftener will probably give better results.

Some growers maintain that it is bad practice to irrigate potatoes at blooming time. There is no available experimental evidence bearing out this conclusion. Utah Station results seem to indicate that the period of full bloom is one of the best times to irrigate. This was the third stage in the experiment cited. Results for application in one stage and for the omission of one stage show the second and third stages to be the critical ones with the third possibly more critical than the second.

Irrigation recommendations may be summarized in the one statement that the ground should be kept moist enough thruout the growing season to permit continuous growth. If the ground dries sufficiently to check growth, there is danger that the tubers will become knobby or gnarled. Sometimes an eye from the bud end sprouts and one or several small tubers are formed at the expense of the original tuber. Such "second growth" is disastrous, for it makes the first tuber soft and soggy as well as causing a high percentage of small, immature tubers.

## IMPROVING THE CROP

Formerly, all seed-stock potatoes were grown entirely in the state. During the last few years, ravages due to mosaic and leafroll and the increasing importance of early potatoes in the trucking areas, have given rise to the importation of considera-able quantities of certified early seed stocks chiefly from Minnesota and Wisconsin. Some late-crop seed potatoes have also come in from the same states but more from Idaho. In some cases the imported seed has been little or no better than local seed stock, but on the whole it has been profitable in trucking areas to bring in seed every second or third season. Experience in buying has greatly improved the chances of getting good seed.

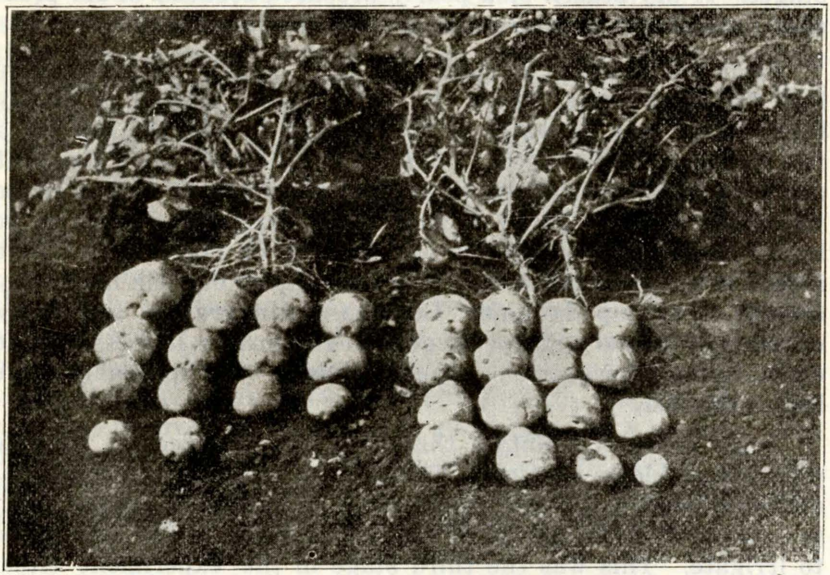


FIG. 16.—Two selected hills. Note the great number of uniform potatoes in each hill. (Courtesy Dr. Geo. R. Hill).

Some half-hearted and short-lived attempts have been made to grow certified early seed potatoes in Utah on a community basis. Just now certain districts are trying again with more promise of success. Many difficulties, including lack of experience, have prevented entire success in this venture. There seems to be no really good reason why hill selection for high-yielding healthy plants and the choice of a favorable area should not furnish the proper physical factors for success. Study and experience on the part of growers and thoro inspection on the part of an authorized state organization would, if pushed vigorously and persistently, be almost certain to result in success.

The Agronomy Department of the Utah Agricultural Experiment Station has shown that it is not extremely difficult by means of hill selection and a seed plat isolated by a few rods from other potato fields to secure and to maintain a high-yielding strain of Rural potatoes. Ohios and Cobblers may be somewhat more difficult to handle, but there is no apparent physical reason why good seed stock even of these varieties might not be grown in the state. Cooperation, knowledge, skill, persistence, and some capital would be required.

Since 1912, seed stock of the Rural variety has been maintained at Logan by hill selection. This consists of choosing for seed those hills that produce a high yield of desirable tubers. If a hill produced other hills exactly like itself year after year, the original selection would be all that was necessary to improve yields. Some plants may themselves be good producers but lack the power to transmit this quality in the next generation. Three or four years are necessary to find out whether the hills selected for seed will produce true to type. The method, however, is so simple as to require but little time or training. The doing of it is what counts.

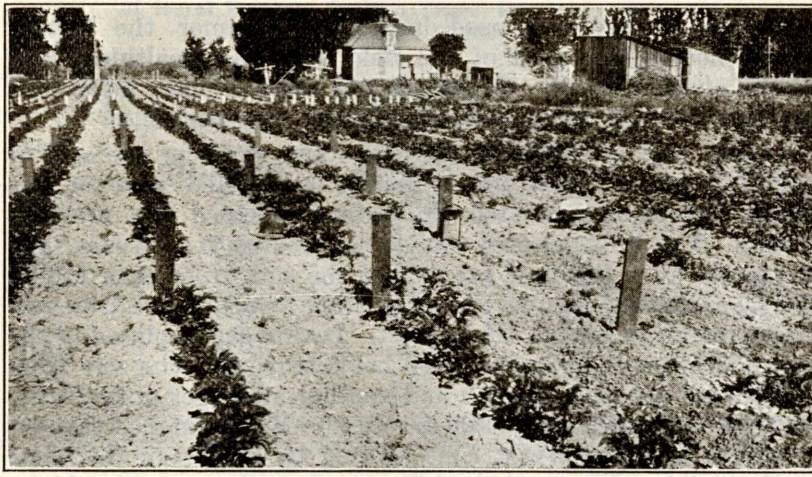


FIG. 17.—View of the potato-breeding plat at the Greenville Farm, Logan, Utah. Each short row extending from one peg to the next was planted from the sets made from one hill. In this way the yielding power of each hill is discovered and the very best are then selected.

Probably the best time to begin selection is rather early in the summer, about the time the vines have reached full size. A large number of small pegs long enough to show above the vines may be used to mark the most promising plants. The whole field should be looked over carefully to find that part of the field where the stand is most uniform. Those vines which look thriftiest and yet have no advantage in extra space, better soil, or more moisture should be "pegged." It may be wise to mark at least double as many hills as the grower wishes to select; four or five times as many will be better.

The time between pegging and harvest gives opportunity for frequent observation of the marked vines. Many of them will fail to maintain the vigor for which they were chosen. The stakes should be removed from these. Just before the general harvest, the farmer should dig the marked hills with a digging fork, leaving each hill by itself. Many of these will be disappointing and some—perhaps half—will be reasonably high-yielding hills of good-shaped, medium-sized potatoes. If two hundred hills are dug but only a hundred selections desired, it may be wise to place these reasonably near each other, and to discard the poorest repeatedly until the number of hills is reduced to the number desired. The selected tubers may be mixed and put into sacks or crates and carefully stored till spring. The more interested farmers will find it profitable to sack each hill separately before storage.

In case no pegs were used during the summer the farmer merely chooses that part of the field that was healthiest and had the evenest stand. He should dig several times more hills than he expects to select, saving only the very best ones.

*A seed plat* is profitable on every farm growing one acre or more of potatoes. This plat is merely a marked part of his field in which are planted the tubers selected the previous autumn. The hills selected should be treated for disease and cut exactly as is the field crop. Let the sets from each hill be kept separate and planted; then a stake should be driven in firmly enough to remain till harvest. If this peg is placed in the row, cultivators or irrigation need not disturb it. The sets from the next hill are then planted and another stake set until all the selections are planted and staked. These will be watched thruout the season and at harvest time all dug by hand—on the same day if possible. When all the hills are dug, the rows should be examined and judged against each other. The unusually poor ones may be discarded entirely as being no better than the ordinary crop. If two or three rows are flatteringly high yielders all the hills of these rows should be saved for a seed plat next year. The year following, this seed plat will grow enough to plant an appreciable part of the general crop. Large growers will find it highly profitable to maintain a selection plat, a test plat, and a multiplication plat every year. Smaller growers will use only one seed plat.

In case no row shows markedly high yields the year following the initial selection, the grower should select the better hills from several of the best rows for a similar plat next year. This should also be done in case a few rows are decidedly high yielders. It is also well to dig from the ordinary crop each fall and to select a few promising hills to add to the selection plat. In a few years considerable improvement can be made in total yield and in the percentage of marketable tubers.

Ontario experimenters selected eleven strains and tested these for three years, after which time acre-yields of 243.4 bushels, 216.3 bushels, and 190.8 bushels were obtained from the best three strains. The average acre-yield in Ontario is about 120 bushels. Colorado growers have also made considerable gains in the same way.

The Utah Station has selected Rural potatoes in this way since 1912. The results are shown to be even more marked than those of Ontario. Table VI gives a brief summary of these results.

TABLE VI.—Summary of Increased Acre-yields Due to Hill Selection of Rural Potatoes for Ten Years, 1915-1924, Inclusive
Logan, Utah

| Year | Acre-yields | | | |
|---|---|---|---|---|
| | Selected Stock (bushels) | Unselected Stock (bushels) | Gain Due to Selection (bushels) | Per cent Increase |
| 1915 | 316.7 | 179.3 | 137.4 | 76.6 |
| 1916 | 330.7 | 191.2 | 139.5 | 72.9 |
| 1917 | 382.4 | 269.3 | 113.1 | 42.0 |
| 1918 | 311.9 | 202.4 | 109.5 | 54.1 |
| 1919 | 146.9 | 117.3 | 29.6 | 25.2 |
| 1920 | 353.4 | 184.8 | 168.6 | 91.2 |
| 1921 | 248.8 | 159.7 | 89.1 | 55.8 |
| 1922 | 598.3 | 284.3 | 314.0 | 110.3 |
| 1923 | 476.6 | 248.7 | 227.9 | 91.6 |
| 1924 | 449.6 | 248.7 | 200.9 | 80.8 |
| Average | 361.5 | 208.6 | 153.0 | 70.1 |

*Rogueing* an isolated seed plat has been found very profitable the last three years. High-yielding strains from the hill-selection experiment, have been planted about 10 rods from other potatoes. At intervals of about a week after the emergence of the young plants, all plants showing mottling, crinkly or rolled leaves, wilting, yellowing or any other abnormality are removed from the plat. Later in the season after tubers are formed, these too are removed when a plant is pulled. During the first year, half or more than half of the plants have been removed. During the second season only a few plants develop such signs of disease or degeneration as to require rogueing. Rogued seed yielded 560 bushels an acre, whereas similar selected but unrogued seed yielded 460 bushels an acre.

## HARVESTING

Except for a few in home gardens, early potatoes are mostly grown in the trucking sections and are usually harvested before maturity for sale on high-priced city markets. The potatoes are small and must therefore bring considerably higher prices than potatoes dug nearer maturity. Kohler[1] at Minnesota made a study of yield at various times of digging with the results shown in Table VII. Since Early Ohio potatoes were used in the experiment, it is somewhat representative of our conditions.

TABLE VII.—The Yield of Early Ohio Potatoes Dug at Different Dates (Minnesota, 1910)

| Date of Digging | Acre-yield Total (bushels) | Acre-yield Marketable (bushels) | Daily Gain Marketable (bushels) | Per cent of Vines Dead |
|---|---|---|---|---|
| July 31 | 38.7 | 10.9 | .... | 0 |
| August 7 | 87.7 | 62.3 | 7.5 | 1 |
| August 14 | 141.5 | 115.4 | 7.6 | 8 |
| August 23 | 203.2 | 182.1 | 7.2 | 22 |
| August 30 | 253.8 | 226.8 | 6.4 | 99 |

From this it can be seen that if only the potatoes are considered it is rather doubtful whether early digging is profitable. The yield was somewhat more than six times as great August 30 as it was July 31. The marketable yield is 20 times as great. Calculations from this table show that with even one or two weeks earlier digging much higher prices must be received. If the price at complete maturity is to be 75 cents a bushel, the grower muost receive $1.29 two weeks earlier and somewhere near $5 four weeks before maturity. Too frequently this difference is not obtained, but sometimes the farmer is safe because he usually uses the land for a late short-season crop such as cabbage, cauliflower, garden beets, or lettuce.

The late crop is usually allowed to grow until all the vines are dead or until danger from frost becomes imminent. This is usually late in September or in October. Later irrigation should be avoided on heavy soils in order to encourage maturity and to prevent the sticking of too much soil to the tubers.

Many small fields are dug by hand with a potato fork or hook. This is hard work and rather slow, but may be cheaper for small areas than the use of horse power. If seed is to be saved from a hand-dug field, the digger should be constantly alert for high-yielding hills to supplement his selection plat.

For digging the larger fields, ordinary stubble or shovel plows are used too generally. They cover or cut too many potatoes to make them desirable implements. Where the area of potatoes grown is too small to justify a digger and where the

[1]Minn. Exp. Sta. Bul. 118, p. 109.

plow is used, it requires considerable care to gather the large number of potatoes covered by the plowing. Volunteer plants, besides carrying over diseases, are a nuisance to the next crop. Small walking diggers are much better than plows and can be obtained at small outlay, especially if three or four farmers buy one cooperatively. It is likely, however, that two acres will pay for a small digger in one season, since they cost only about $20 apiece.

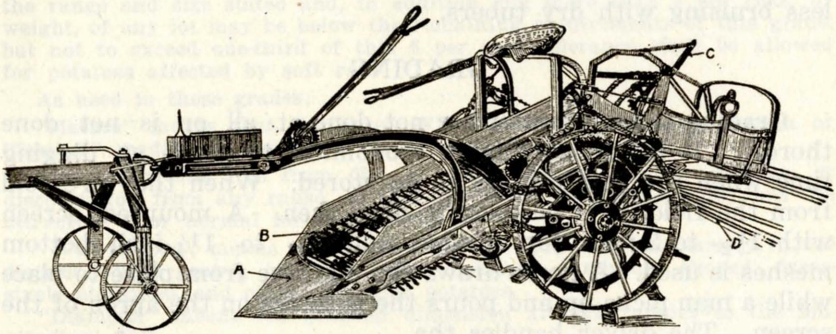



FIG. 18.—Diagram of elevator type of potato digger. A, blade which passes under hills; B, elevator rods; C, spring release for throwing off vines; D, device for separating very large tubers from those of medium size.

In sections that grow considerable areas for market, most growers are using the elevator digger, or at least they should be. The blade of the digger passes under the hills, and the elevator carries them up and shakes off the dirt. Some have grading attachments on them, but another machine is usually used for this operation. The large diggers cost from $80 to $150 and require four horses for efficient draft. In some districts many potatoes are injured by setting the blade of the digger too near the surface. It would pay to use another horse and set the blade below the hills. Three to five acres can be harvested in a day with one digger and an efficient crew. Compact soils increase the draft tre-

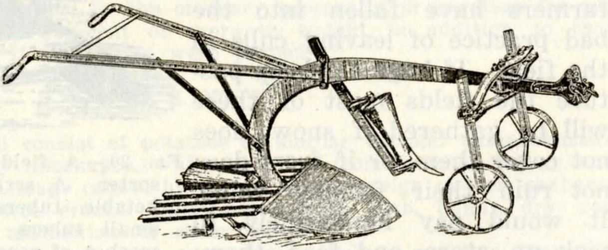


FIG. 19.—Small potato digger. This implement is much better than a plow. The bars behind the blade are jerked up and down by means of revolving arms beneath. This jerking motion shakes off some of the dirt.

mendously; here is another good reason for more careful plowing, manuring, and irrigation.

Picking is frequently done immediately behind the digger. It is usually wise, however, for the potatoes to lie on the ground for about an hour. This allows any dirt on the tuber to dry and moisture from the skin to evaporate before grading and sacking. Dry dirt rattles off in handling, and fewer potatoes spoil in storage or during shipment. It is also likely that there will be less bruising with dry tubers.

## GRADING

Grading is too often either not done at all or is not done thoroly. It is probably more economical to grade at digging time when the potatoes are to be stored. When they are sold from the field, it is necessarily done then. A mounted screen with 1½- to 2-inch top meshes and ¾- to 1¼-inch bottom meshes is used. A horse draws the machine from place to place while a man picks up and pours the potatoes on the apron of the screen. The driver handles the machine while a third sews or ties the sacks and assists in loading or picking.

Too little good grading is done for the benefit of the farmer. He usually gets less for his ungraded crop, and besides, loses the culls for feed. Some farmers have fallen into the bad practice of leaving culls in the field. If hogs or sheep pasture the fields most of these will be gathered if snow does not cover them, or if frost does not ruin their feeding value. It would pay handsomely to pick up, store, and feed them. Moreover, the next crop on the land would not be troubled with volunteer potatoes as weeds. Rotations might also be a year shorter under a system of clean harvesting because volunteer potatoes are usually badly diseased.

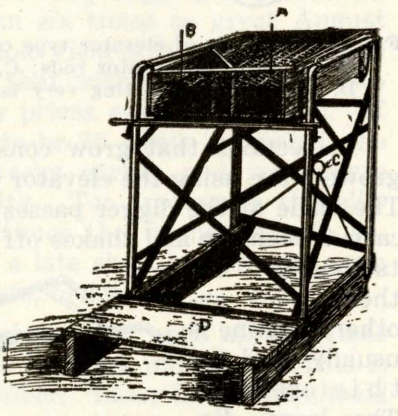


FIG. 20.—A field potato grader and sorter. A, screen over which marketable tubers pass; B, exit for small tubers that go thru the meshes of screen A; C, device for hitching horse to grader; D, platform for sack and driver who handles the sacks.

The U. S. Department of Agriculture recommends the adoption of the following grades:

## U. S. FANCY NO. 1

U. S. Fancy No. 1 shall consist of potatoes of one variety which are mature, bright, well-shaped, free from freezing injury, soft rot, dirt or other foreign matter, sunburn, second growth cracks, hollow-heart, cuts, scab, blight, dry rot, disease, insect or mechanical injury, and other defects. The range in size shall be stated in terms of minimum and maximum diameters or weight following the grade name, but in no case shall the diameter be less than 2 inches.[1]

In order to allow for variations incident to proper grading and handling, not more than 5 per cent, by weight, of any lot may vary from the range and size stated and, in addition, not more than 6 per cent, by weight, of any lot may be below the remaining requirements of this grade, but not to exceed one-third of this 6 per cent tolerance shall be allowed for potatoes affected by soft rot.

As used in these grades:

"Mature" means that the outer skin (epidermis) does not loosen or "feather" readily during the ordinary methods of handling.

"Bright" means free from dirt or other foreign matter, damage or discoloration from any cause, so that the outer skin (epidermis) has the attractive color normal for the variety.

"Well-shaped" means the normal, typical shape for the variety in the district where grown, and free from pointed, dumb-bell shaped, excessively elongated, and other ill-formed potatoes.

"Diameter" means the greatest dimension at right angles to the longitudinal axis.

"Free * * * from damage" means that the appearance shall not be injured to an extent readily apparent upon casual examination of the lot, and that any damage from the causes mentioned can be removed in the ordinary process of preparation for use without appreciable waste in addition to that which would occur if the potato were perfect. Loss of outer skin (epidermis) shall not be considered as an injury to the appearance.

"Badly misshapen" means of such shape as to cause appreciable waste in the ordinary process of preparation for use in addition to that which would occur if the potato were perfect.

"Free from serious damage" means that any damage from the causes mentioned can be removed by the ordinary process of preparation for use without a waste of 10 per cent or more, by weight, in addition to that which would occur if the potato were perfect.

## U. S. NO. 1

U. S. No. 1 shall consist of potatoes of similar varietal characteristics which are not badly misshapen, which are free from freezing injury and soft rot, and from damage caused by dirt or other foreign matter, sunburn, second growth, growth cracks, hollow-heart, cuts, scab, blight, dry rot, disease, insects, or mechanical or other means.

The diameter of potatoes of round varieties shall be not less than 1⅞ inches and of potatoes of long varieties 1¾ inches.

In order to allow for variations incident to proper grading and handling, not more than 5 per cent, by weight, of any lot may be below the prescribed size, and, in addition, not more than 6 per cent, by weight, may be below the remaining requirements of this grade, but not to exceed one-third of this 6 per cent tolerance shall be allowed for potatoes affected by soft rot.

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[1]Such statements as the following will be considered as meeting the requirements: "U. S. Grade Fancy, 2 to 3¼ inches"; "U. S. Grade Fancy, 10 oz. to 16 oz."; "U. S. Grade Fancy, 2 inches and larger"; "U. S. Grade Fancy, 10 oz. and larger".

## U. S. NO. 1 SMALL

U. S. No. 1 Small shall consist of potatoes ranging in size from 1½ inches to 1⅞ inches in diameter but meeting all the other requirements of U. S. No. 1.

In order to allow for variations incident to proper grading and handling not more than 25 per cent, by weight, of any lot may vary from the prescribed size, but not to exceed one-fifth of this tolerance shall be allowed for potaoes under 1½ inches in diameter. In addition not more than 6 per cent, by weight, may be below the remaining requirements of this grade, but not to exceed one-third of this 6 per cent tolerance shall be allowed for potatoes affected by soft rot.

## U. S. NO. 2

U. S. No. 2 shall consist of potatoes of similar varietal characteristics which are free from freezing injury and soft rot and from serious damage caused by sunburn, cuts, scab, blight, dry rot, disease, insects, or mechanical or other means.

The diameter of potatoes of this grade shall be not less than 1½ inches.

In order to allow for variations incident to proper grading and handling, not more than 5 per cent, by weight, of any lot may be below the prescribed size, and, in addition, not more than 6 per cent, by weight, may be below the remaining requirements of this grade, but not to exceed one-third of this 6 per cent tolerance shall be allowed for potatoes affected by soft rot.

# STORAGE

A good storage place for potatoes is one of the essentials to successful potato production. Some storage is required every season even when the commercial crop is marketed at harvest time. Seed stock for the next season's planting must be saved, and small quantities for home consumption are usually profitable. Many growers, perhaps most of them, find it profitable to store culls for livestock feeding. Since small space is usually ample for these purposes, it is only where appreciable quantities are stored for later marketing that storage facilities receive serious attention.

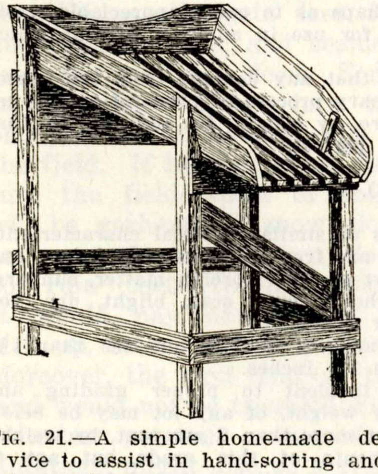

FIG. 21.—A simple home-made device to assist in hand-sorting and in sacking.

## FACTORS IN STORAGE

**The principles involved** do not differ greatly whether a few bushels or several hundred are stored, or whether pits, cellars or warehouses are used. Only the mechanism varies: the purposes to be accomplished and the end arrived at are identical. The chief purpose is the maintenance of the potatoes in a firm, uninjured condition until the time of disposal. The factors that influence storage are temperature, aëration, size of the pile or bin of potatoes, light, humidity, and dry rot. To control each of these factors in the way or to the degree necessary for successful storage is the end aimed at.

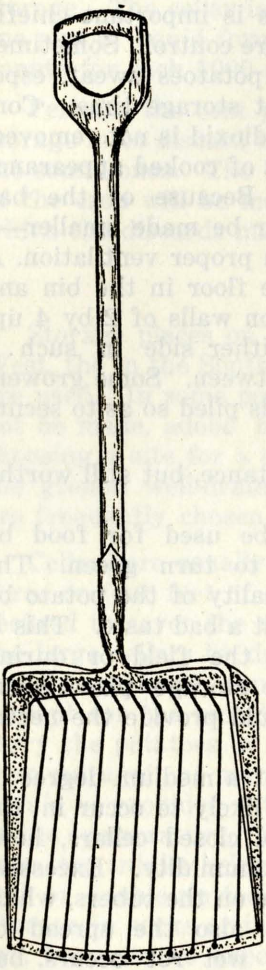

FIG. 22.—A good type of fork for handling potatoes. The blunt plate in front of the tines prevents the tubers from being punctured.

The best temperature for storage is somewhere between 36° F. and 40° F. This maintains the firmness of the tubers by reducing the evaporation and the loss due to respiration to a minimum. It must not be forgotten that living plants as well as living animals breathe all the time they are alive. At a low temperature potatoes pass into a dormant period during which breathing goes on very slowly. As the temperature increases the rapidity of breathing greatly increases. Starch is consumed by rapid respiration and the tubers soften and lose weight. The tubers are not injured by frost until a point three or four degrees below the freezing point of water is reached, but potatoes held for any great length of time near 32° F. acquire a sweet taste when cooked. At 36° F. and at higher temperature this sweet taste does not develop, because starch does not change to sugar in any quantity as it does at lower temperatures. Above 40° F., respiration is so active as to cause appreciable loss. Precautions must therefore be taken to reduce temperatures, especially if the potatoes are stored during hot weather.

**Aëration, or ventilation,** of the storage place is essential in order to carry off the water and the carbon dioxid which are excreted in breathing. The air expired from an animal is laden with water vapor and with foul gases, chiefly carbon dioxid. The products of plant respiration are the same. Dr. George R. Hill[1] has has shown that peaches and other living plant tissues become brown and lose firmness much more rapidly in an atmosphere rich in carbon dioxid than in normal air. This undoubtedly applies to potatoes in storage. Aëration is therefore essential.

**The size of the pile or bin** of potatoes is important chiefly as it has to do with aëration and temperature control. Sometimes when deep and wide piles are made the potatoes sweat, especially if they were somewhat immature at storage time. Considerable heat is given off and the carbon dioxid is not removed. In extreme cases, the tubers take on a sort of cooked appearance and deteriorate rapidly into a soft pulp. Because of the bad effects of over-heating, piles should either be made smaller—4 to 6 feet deep—or should be provided with proper ventilation. A good way of doing this is to have a false floor in the bin and at intervals of 4 or 5 feet to make partition walls of 2 by 4 uprights with narrow boards fastened on either side in such a way as to leave a space of about an inch between. Some growers and wholesalers use crates, sacks, or barrels piled so as to secure aëration.

**Light and humidity** are of lesser importance, but still worthy of attention.

Sunlight injures potatoes that are to be used for food by causing them to develop chlorophyll and to turn green. The chlorophyll greatly injures the cooking quality of the potato by causing it to become soggy and by giving it a bad taste. This is true whether the exposure takes place in the field or during storage. It is therefore best to have the storage place absolutely devoid of sunlight. Electricity should provide the necessary lighting.

The humidity is best when the air is of a medium degree of dampness. Extremely dry air, such as is likely to occur in the West, causes excessive evaporation. Cool closed cellars, however, soon acquire the proper degree of humidity. Excessive moisture causes a condensation of moisture on the tubers, which unless removed, encourages heating and also the spread of storage diseases, such as dry rot. A soft wet rot occurs, but much less frequently. In California a disease called "leaks" causes trouble, particularly where the potatoes have been wounded or the knobs broken off. This disease causes water to be drawn from tubers sometimes rapidly enough to drain away from piles in streams.

**Dry rot** is caused by a Fusarium but by a different species from that causing the Fusarium wilt. Only cut, bruised, broken,

[1]Cornell Expt. Sta. Bul. 330, p. 405.

or skinned potatoes are ordinarily attacked by this disease, tho in a storage place that is too warm and too humid even the sound tubers may be injured. Correct storage temperature and abundant aëration prevents the rapid spread of dry rot in bins. Cellars should be fumigated before putting each harvest in storage. The cellar is made air-tight and fumigated by pouring one pint of liquid formalin over 23 ounces of potassium permanganate for each 1000 cubic feet of space.

Perhaps the best possible method of avoiding dry rot in storage is to discard in the field all injured tubers, storing only the sound ones. The keeping quality and the total market value of the crop will be increased by careful grading, in addition to which the discards may be fed to livestock.

## STORAGE PLACES

Storage places on the farm are either pits or cellars in the West, tho in the South and in Maine specially constructed houses are used. In some poorly drained areas where excavations cannot be made, adobe houses are used to good advantage. In choosing a site for a cellar or pit it is highly important to have the ground well-drained. Because of this, side hills or knolls are frequently chosen.

**Cellars** are usually partly underground and partly above. If three or four feet of excavating is done, about enough dirt is secured to cover the roof. The potatoes are best unloaded into the large cellars by driving in the wagons and into smaller cellars by means of chutes. Too many farm cellars are inconvenient for the reception or for the removal of potatoes. To carry the potatoes in sacks or in baskets down cellar steps and then out again at market time is too expensive in labor. Cellars should be provided with flues for ventilation and for the control of the temperature. A top and a bottom flue are counted necessary, the intake being at the bottom. The use of false floors and of double-slatted partitions greatly facilitates ventilation. Storage in sacks or in crates is also a great advantage. They are, however, so expensive as probably to make bulk storage inadvisable for the ordinary market crop. Selected seed is best kept in crates.

**Pits,** like cellars, should be built only on well-drained land. An excavation of six to twelve inches should be lined with straw and then filled with potatoes in the shape of an inverted V as high as they will stand without danger of tumbling down. A layer of straw that will be six or eight inches thick when compressed is placed over the potatoes and three or four inches of dirt scattered evenly over this. Flues at intervals of a few feet should extend to within about six inches of the floor of the pit. The flues should have perforations made by auger borings and should have covers to keep out rain and snow and yet be open. The openings permit easy ventilation and yet allow being closed entirely in extremely cold weather.

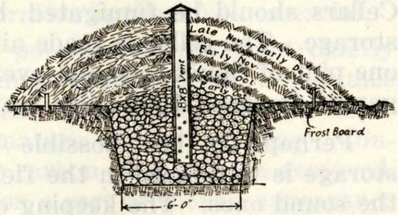

FIG. 23.—Diagram of a pit filled with potatoes. The tubers could be piled somewhat higher than indicated in the diagram. Ventilation is provided by means of the wooden spout which serves as a vent, having auger holes in the lower part which reaches into the pile of potatoes and having openings under the eaves at the top.

One layer of straw and a thin one of dirt allows the potatoes to cool down without danger of freezing. As cold weather comes on, another layer of straw and a thicker one of earth is added. In regions where temperatures from 10° F. to 20° F. below zero are reached a third layer is probably advisable. About eight inches of earth may be put on at this last last covering.

Long, narrow pits are recommended rather than wide, open ones because aëration is accomplished more readily. It is also counted better practice to store in small pits, since these are less likely to heat than are large ones, and since the loss is smaller should heating or rotting occur. When spoiling commences in a pit, often all the potatoes in it are lost. Many growers feel it wise to have pits small enough to empty the day they are opened, either by sale or by storage in a cellar. Danger from freezing or from heating seems to be somewhat greater after a pit is once opened. Pits have the advantage of being cheaper than cellar storage space, and the disadvantage of being inconvenient and unhandy when the farmer wishes to examine the potatoes. Their best use is probably merely as a supplement to cellar storage.

## MARKETING

Whether to market his potatoes at harvest time or to store them in the hope of getting higher winter and spring prices is always a problem with the grower of late potatoes. Frequently considerable profit is made by holding the crop; occasionally there are enormous advances in price, as during the winter of 1916-17 when the April price was around three dollars a bushel. These high profits would encourage storage were it not for the fact that occasional "slumps" occur, when "the bottom drops out of the market." The winter of 1917-18 was nearly as disastrous for the man who stored his potatoes as the season of 1916-17 was profitable.

A brief analysis of these two years may help to explain the problem. In 1916 the "Monthly Crop Report" for October estimated the crop at 301 million bushels for the United States, but as the season had been decidedly unfavorable, the yields were injured more than had been anticipated and only 285 millions were harvested. The normal consumption, which for the last twenty years has been nearly 3.5 bushels per capita, had to be largely curtailed. In other words, the demand exceeded the supply by about 100 million bushels. The farm price, which on November 1 was about $1.25 a bushel, advanced steadily to $3 a bushel or thereabouts at planting time. So great was the visible shortage that any person who had followed the crop reports could have predicted a marked advance in price.

The same is true for the 1917 crop, in that anybody could have predicted a "slump". The acreage had been increased materially due to the high price of the 1916 crop and due to the urging of the National Food Administration. This, coupled with the unusually high acre-yields due to an extremely favorable season, gave a decided over-production. Prices were reasonably good at harvest. Field men from the Bureau of Markets were urging farmers to "release" their potatoes, but the fabulous prices of 1916-17 had produced "itching palms". In the spring the market broke, completely overloaded. Prices dropped to 15 or 20 cents where buyers could be found. Thousands of bushels were left to rot in the pits or were carted off to garbage heaps.

The year 1921 resembled 1916 and the year 1922 resembled 1917 except that the scarcity of 1921 was not so great as that of 1916. Overproduction in 1922 was even greater than in 1917, and the effect on price was the same.

Years either of unusually high, or of unusually low, production permit almost certain prediction of the price. It is, however, but seldom that these unusual seasons occur. It is the nearly normal years that cause difficulty in estimating the price after storage. Taking the United States as a whole, it is safe to say that to store year after year is not good practice because, on the average, prices advance only about 6 per cent from December 1 to March 1, whereas the loss due to shrinkage and to disease is about 8 per cent. In addition to this, the grower has the extra expense and labor of storage. The West, however, is so far from the great markets that some sort of farm storage is necessary in order to avoid local "slumps" due to dumping all of the crop on a market poorly provided with cars or with warehouses. Some sort of central marketing organization is needed to avoid such local congestion, to prevent a general storage at the wrong time, and to encourage one when prices promise materially to advance.

Livermore[1] made a study of the relation of production to price and found that in seasons of normal production the farm price was about 54 cents a bushel. He gives the data found in Table VIII to show how the production affects the price.

TABLE VIII.—The Relation of Potato Production in the United States to Fall Price. (1866-1916)

| Production Compared to Normal (per cent) | Average Farm Price (December 1) |
|---|---|
| 75 or less | $0.94 |
| 76 to 85 | .65 |
| 86 to 95 | .60 |
| 96 to 105 (normal) | .54 (normal) |
| 106 to 115 | .42 |
| 116 to 125 | .43 |
| Over 125 | .35 |

Potatoes are so sensitive that seasonal conditions cause the acre-yields to vary widely. The most important single factor in determining the yield of potatoes is therefore at the disposal of neither grower nor buyer. All that can be done is to secure monthly crop estimates from the U. S. Department of Agriculture. Any person may obtain these reports by writing to the Chief, Division of Publications, U. S. Department of Agriculture, Washington D. C. Careful investigations of the acre-yields and prices have shown that between 1866 and 1924 prices were high when the acre-yields were low, and vice versa. This is not an "average", not a "general statement", but one that expresses the conditions each year.

Gilbert[2] gives the following as the expense of marketing potatoes:

| | |
|---|---|
| Retailer | 15-30 cents |
| Wholesaler | 5-10 cents |
| Transportation | 8-10 cents |
| Large distributor | 3- 4 cents |
| Sacks and car linings | 3- 5 cents |
| Local dealer | 5-11 cents |
| Total | 39-70 cents |

[1]Cornell Rural School Leaflets, Vol. X, p. 151.
[2]"The Potato" (Macmillan, 1917), p. 255.

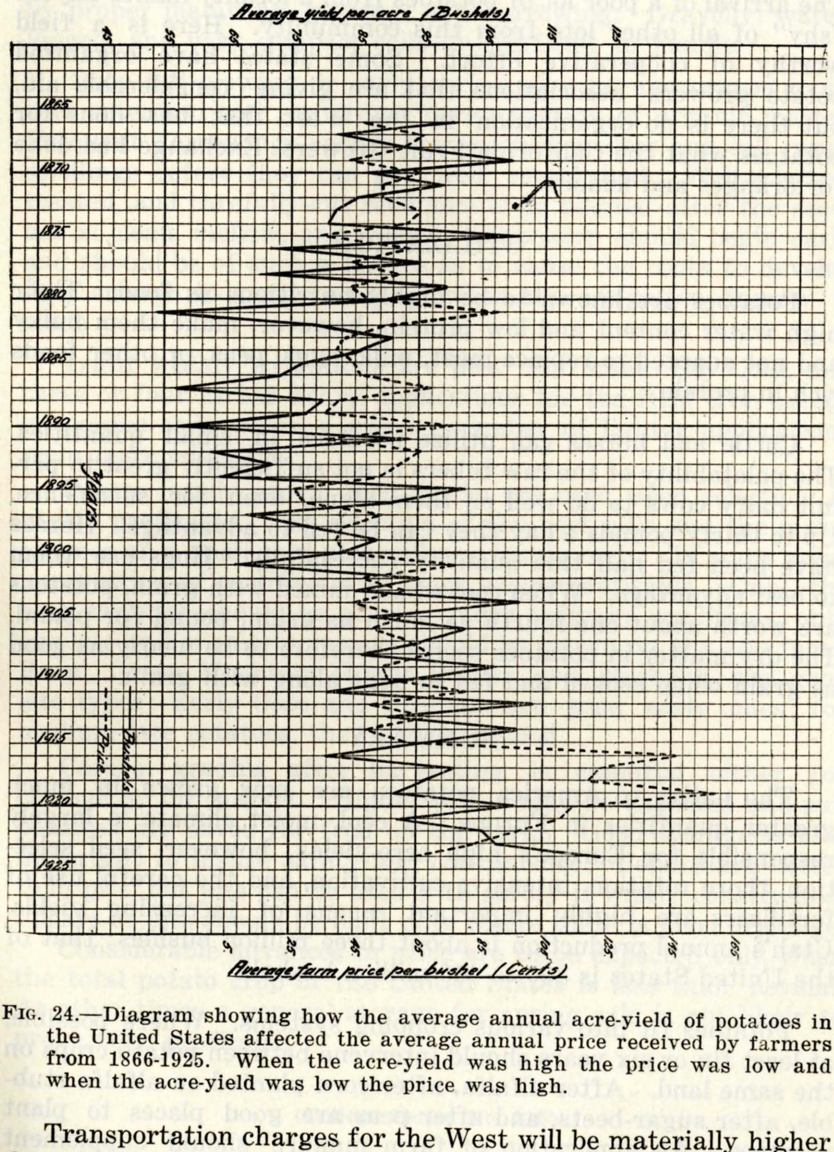


FIG. 24.—Diagram showing how the average annual acre-yield of potatoes in the United States affected the average annual price received by farmers from 1866-1925. When the acre-yield was high the price was low and when the acre-yield was low the price was high.

Transportation charges for the West will be materially higher than those given. Because of this and because of danger of loss in transit, great care should be exercised in grading potatoes for long shipment. Not only should they be graded according to size, but also according to quality. Bruised, frozen, rotten, or otherwise injured tubers should not be included. This is a community problem, because a single grower with a crop bearing blemish will not discard a large part of it on his own initiative.

The arrival of a poor lot of potatoes from a locality makes buyers "shy" of all other lots from this community. Here is a field worthy of coöperative effort. Some states have organized potato growers' associations that are giving considerable aid, but there is no organization in the West that has done for potatoes what the California Fruit Growers' Exchange has done for oranges and lemons.

## UTILIZATION

Potatoes are known to be highly nutritious as food. Their high water content and low protein, however, make them bulky and not adapted to replace meat, milk, eggs, peas, or other foods rich in protein.

Cattle and horses can utilize potatoes in small quantities. The palatability of the raw tubers is not sufficiently great to permit dairy cows to do well on them alone, even for succulence. Up to thirty pounds a day they can be fed to advantage. Horses have been fed half this quantity successfully. Hogs use them to best advantage. When cooked and mixed with grain, potatoes are worth about one-fourth as much as grain, pound for pound. The dry matter in potatoes seems therefore to be nearly as good as grain when cooked and fed to hogs along with grain.

## SUMMARY

Tho native to America potatoes are now grown in much greater quantities in Europe. A cool, moist climate is largely responsible for Europe's high acre-yields; however, seed selection, thoro rotation, intensive cultivation, and the careful use of fertilizers are highly important means of increasing yields. Utah's annual production is about three million bushels; that of the United States is 350 to 450 million bushels.

Potatoes fit into various cropping systems. Where possible, at least fix or six years should intervene between potato crops on the same land. After alfalfa, after corn planted on alfalfa stubble, after sugar-beets, and after peas are good places to plant potatoes. An application of farm manure should supplement rotation. Moderate quantities of manure are best except in trucking areas where heavy applications are profitable. Manure is best applied and turned under as early as possible, preferably in the fall or early winter.

Sandy loam soils are best adapted to potatoes. Any of the well-drained soils may be made reasonably good for potatoes by proper manuring, plowing, and harrowing. Gravelly, water-logged, and very compact soils are difficult to handle.

Deep fall plowing or early spring plowing encourages moisture retention and the proper decomposition of organic matter. Frequent harrowings render the seedbed mellow and kill weed seedlings before they can get well established. Well-selected, treated, and carefully-cut seed should be planted after the seedbed is clean, mellow, and warm. Cultivation should begin early and should be of such a nature as to cause the roots to develop deep enough to avoid being cut when the irrigation furrow is made.

Light weekly irrigations are best for small city lots, and three or four rather heavy applications for the field crop except on porous soils where a greater number of lighter applications seem more advisable.

Where locally grown seed stocks are used, seed selection is highly profitable. The selection of the best hills and the maintenance of a small seed plat will pay handsomely. In some areas importation of certified seed stock seems profitable. Only the best varieties should be grown; under ordinary conditions, only one late and one early variety should be grown on any one farm. Rural, Green Mountain (Idaho Rural) and Burbank are good late types; Early Ohio and Triumph are good early ones; for medium late potatoes, the Cobbler is good.

Careful grading after harvesting is essential either for storage or for market. Higher prices may be expected and cull potatoes are saved for feed on the farm. Good storage is also important to insure safety and convenience. Cellars are better than pits, but pits can be used with safety if wisely constructed. Cellars or pits should be built only where there is good drainage.

Considerable advances in price are to be expected only when the total potato crop of the United States is less than normal. At other times a general storage for spring sale is not likely to prove very profitable.

(College Series No. 213)

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*"We praise all the flowers in fancy,*
*Sip the nectar of fruit ere they're peeled,*
*Ignoring the common old tater*
*When, in fact, he's the King of the Field.*
*Let us show the old boy we esteem him,*
*Sort of dig him up out of the mud;*
*Let's show him he shares our affections*
*And crown him with glory—'King Spud.'"*